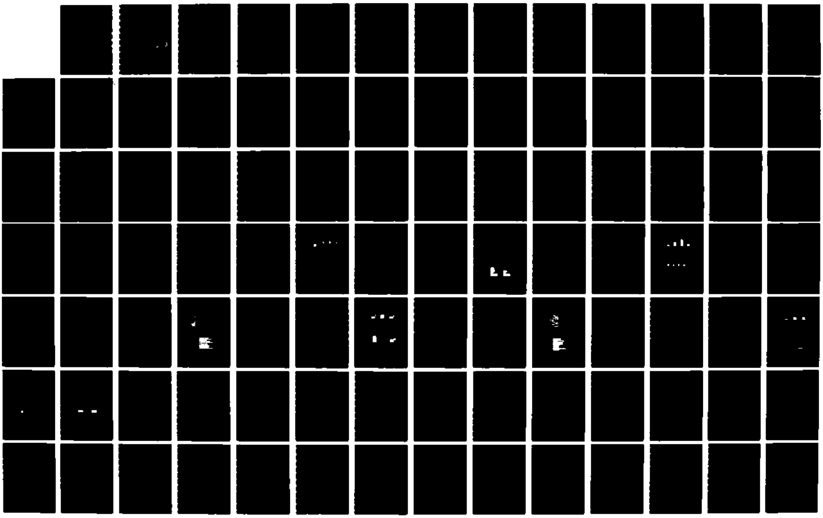
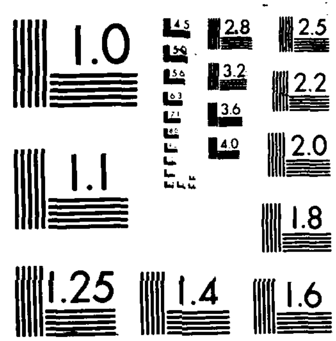
AD-A175 196 AN OBJECTIVE EVALUATION OF DETERMINANTS OF CONSTRUCTION 1/2
PROJECT SUCCESS(U) ARMY MILITARY PERSONNEL CENTER
ALEXANDRIA VA R A SALIMBENE DEC 86

UNCLASSIFIED F/G 5/1 NL





CROCOPY RESOLUTION TEST CHART

(2)

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

AD-A175 196

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A175196	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) An Objective Evaluation of Determinants of Construction Project Success		5. TYPE OF REPORT & PERIOD COVERED Final Report, 26 November 86
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Rory A. Salimbene, Captain, U. S. Army		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Student, HQDA, MILPERCEN (DAPC-OPA-E) 200 Stovall Street Alexandria, Virginia 22332		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS HQDA, MILPERCEN, ATTN: DAPC-OPA-E 200 Stovall Street Alexandria, Virginia 22332		12. REPORT DATE 26 November 1986
		13. NUMBER OF PAGES 98
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Thesis, University of Texas at Austin

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Construction; construction management; project management; project success.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Factors contributing to outstanding outcomes for major construction projects are identified and evaluated in this report. The report documents the results of an extensive research project undertaken at the University of Texas to determine what causes outstanding projects to differ from average ones. Possible factors were identified through exhaustive literature review and in-depth interviews with highly experienced construction management personnel. Objective data was gathered for each of 21 potential factors from 26 major

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Block 20 (cont):

construction projects. This data was then evaluated using rigorous statistical tests to determine the significant differences between average and outstanding projects. The report concludes with specific recommendations for construction project managers based on the observed findings.

An Objective Evaluation of Determinants of Construction Project Success

CPT Rory A. Salimbene
HQDA, MILPERCEN (DAPC-OPA-E)
200 Stovall Street
Alexandria, VA 22332

Final Report, 25 November 1986

A thesis submitted to The University of Texas at Austin in partial fulfillment of the requirements for the degree of Master of Science in Engineering.

AN OBJECTIVE EVALUATION OF DETERMINANTS OF CONSTRUCTION PROJECT SUCCESS

by

RORY ALAN SALIMBENE, B.S., P.E.

THESIS

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE IN ENGINEERING

THE UNIVERSITY OF TEXAS AT AUSTIN

December 1986

ACKNOWLEDGEMENTS

Grateful acknowledgement is made to the individuals and companies who participated in the research. Without their willing cooperation in the giving of their time and information, this work would not have been possible.

Dr. David B. Ashley is recognized for the guidance and supervision provided throughout the course of the research. The additional insight provided by him made an invaluable contribution to this work.

Kate Barnes assistance in the data reduction and statistical analysis was instrumental in the successful completion of this thesis. Many thanks are due to her for her perserverance in dealing with the really tedious aspect of the work.

Ed Jaselskis is recognized for his invaluable assistance in the identification of data requirements and collection of the data for this study. Without his help, much less data and consequently much less meaningful results could have been obtained.

Finally, many thanks are due my wife Becky, whose support during the past year has been continual source of encouragement.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

I.1 Introduction

Efforts to improve construction project execution have been in evidence through the ages. Considering the relative size of the industry, minimal improvements in project performance have significant financial implications. In the United States alone, a one percent improvement in project cost performance in 1985 construction contracts would have amounted to additional profits of 1.3 billion dollars for the construction industry.[1] Obviously, incentives and justification exist for attempts to identify means with which we can improve construction project performance.

Along with being the largest industry in the United States, the construction industry is also probably the most diverse in terms of both products and methods. Several different methods exist for accomplishing every construction management task. The relative success of these methods varies as well. By and large, these methods have been developed by individual organizations through practice and experience, with limited sharing among organizations.

Construction projects are executed with varying levels of success. Perhaps the most vivid portrayal of the lower end of the spectrum is an unfinished nuclear power plant that may

[1] "Construction Economics", Engineering News Record, January 23, 1986, pp. 53-58.

remain unfinished because both the resolve and financial resources of the project sponsors have been stretched to their respective limits by tenfold increases in costs. On the other hand, every manager in the construction industry can cite a project that far exceeded everyone's performance expectations and is recognized as a resounding success. Clearly, the circumstances in the first example are to be avoided at all costs. Equally as clear, however, is the desirability of reproducing the outcomes in the second example.

The body of literature related to this particular field is extensive. Pages and pages of articles can be found which attempt to prescribe methods by which we may prevent the circumstances of the first example cited above. A similar number of articles can be found which detail specific approaches to particular problems or construction management related issues. There exist reams of information which prescribe methods of successfully performing the management activities related to construction projects. By and large, however, all of this information is oriented towards avoidance of failure. Somewhat limited, however, are articles addressing those specific actions which lead to outstanding outcomes. Considering the likelihood that failure avoidance does not necessarily imply outstanding outcomes, justification may exist for additional research in this regard.

Clearly, strictly economic considerations provide significant justification for attempts to repeat outstanding construction project outcomes. If we are successful in identifying the means to do this on a continuous basis, we will be able to establish a new baseline for construction project performance. This exciting possibility provides the impetus for

this research effort. We hope to tap the broad base of industry experience with outstanding project outcomes to identify, through a compilation and analysis of these shared experiences, the means by which we can repeat construction project success.

I.2 Research Objective

Central to our study is the premise that construction project success is repeatable. This implies that it is possible to identify those management actions and investments which, if repeated, will lead to successful outcomes. Our research is directed towards identifying those construction project management methods, actions, and investments which lead to project outcomes that far exceed outcomes that would normally be expected. We hope to identify those actions which deserve the greater portion of finite management time and financial resources.

Our intent is to base our conclusions upon an objective evaluation of actual construction industry practices and experiences. We intend to <u>objectively</u> measure management inputs and project outcomes for a wide variety of major construction projects and then rigorously analyze the information obtained in an effort to identify those inputs that differ between projects with outstanding outcomes and projects with average outcomes. In that regard, our work will be a significant departure from other work in the field because of our emphasis upon the differences between <u>average</u> and <u>outstanding</u> projects, rather than an analysis of the differences between successful and unsuccessful projects. In other words,

we do not seek to identify the means by which construction project failure can be avoided. Rather, we hope to identify the appropriate actions to make good projects better.

I.3 Report Organization

The remaining four chapters provide the reader with necessary background, describe data collection and analysis, present detailed findings, and provide recommendations for management actions and further research. The thesis is organized as described in the following paragraphs.

Chapter I provides an introduction to the subject and includes this brief description of the contents of the thesis.

Chapter II provides necessary background information. It includes a section devoted to a brief literature review of current work in this field, a summary of the previous research completed in this research project, and a detailed review of the study methodology.

Chapter III provides detailed information regarding the data collection process. Included is a description of the data and the data collection process, a summary of the project sample characteristics, and a discussion of the difficulties encountered in the process.

Chapter IV describes the findings of this study in detail. Five major categories of findings are included. One section is devoted to a discussion of project performance and characteristic differences between average and outstanding projects. Three sections discuss the impact of the different

factors upon overall project outcomes, project schedule performance, and project budget performance, respectively. A final section discusses those factors which do not appear to impact any of the above.

Chapter V details our recommendations to managers. Additionally, the limitations of the study are outlined and further research requirements are identified. Concluding comments regarding the success of our effort and its implications comprise the final section of Chapter V.

CHAPTER II

BACKGROUND

II.1 Summary of Other Work

Much has been written regarding successful project management. The literature encompasses a broad range of project types and sizes and is either prescriptive or descriptive in nature. Most of it is limited to the study of a particular project input or project type. Many are simply case studies of particularly successful projects. The aggregate of these studies has provided the starting point for this research through the identification of potential factors which are determinants of outstanding project outcomes.

Of immediate concern to this or any other study regarding determinants or preconditions of success is the definition of success. Several papers presented at the 1986 Project Management Institute Symposium directly address this issue. Several different and in some cases opposing conclusions have been drawn by the seminar's participants. One author states that objective measurement of project success is merely an impossible illusion due to dynamic project objectives which change over time, participation by multiple participants with multiple objectives, and the totally subjective nature of many of the desirable project outcomes.[2] Despite this view, many of the articles seek to describe methods of measuring success for one

[2]de Wit, Anton, "Measuring Project Success: An Illusion," 1986 Proceedings, Project Management Institute, pp. 13-21.

or all parties to a project. A central theme throughout many of the articles is the different measures of success which exist for the various participants. One article seeks to limit the truly successful project (at least in the utility arena) to one which satisfies the criteria used by all parties involved in the enterprise.[3] Others prescribe particular techniques or systems which may be used to determine the level of success of a project. These include project team audits,[4] productivity measurements,[5] and numerous other specific criteria or methods.

In addition to the issue of a definition for success, other articles prescribe preconditions, procedures, or factors for achieving success. One author identifies 17 factors related to the "state of health" of the project organization and the "professionalism" of the project team which should be audited during the early stages of the project to insure that success is being produced.[6] Another article holds that the key to project success is the building of a winning project team.[7] Yet another article develops the characteristics of a successful project manager, which is presented as the key to a successful project.[8]

---

[3]Salapatas, J. N., and Sawle, W. S., "Measuring Success of Utility Projects Past Present and Future," 1986 Proceedings, Project Management Institute, pp. 67-76.

[4]Jolivet, François, and Batignolles, Spie, "The Possibility of Anticipating, Several Years in Advance, the Success or Failure of a Project," 1986 Proceedings, Project Management Institute, pp. 35-39.

[5]Herbsman, Zohar J., "Realistic Production Rates the Key For Measuring Construction Success," 1986 Proceedings, Project Management Institute, pp. 348-353.

[6]Jolivet, pp. 35-39.

[7]Tuman, John Jr., "Success Modeling: A Technique for Building a Winning Project Team," 1986 Proceedings, Project Management Institute, pp. 94-108.

[8]Kothari, Ashok K., "Success in Project Management," 1986 Proceedings, Project Management Institute, pp. 240-246.

The research outlined above represents a cross section of ongoing work in this field. All of it represents valid efforts to analyze the concept of project success. Quite clearly, there are many different and in some cases opposing theories regarding the measurement and achievement of project success. A more detailed analysis of this body of work will identify the differences as a result of either different viewpoints (client, owner, public), different perspectives (project success as opposed to project management success), different project types (construction, R & D, others), specialization (project team, project manager, project controls), or different definitions of success (exceeding expectations as opposed to achieving them). A minority of the articles provide data to support the assertions. In any event, this work is summarized here to provide the reader with the opportunity to discriminate our work from others. This discrimination should be based upon the viewpoint (project management success), the definition of success (exceeding expectations), and project type (construction). Most importantly, however, we intend to collect actual data from a cross section of projects in order to validate our results. In this way, we hope to provide the evidence to support the assertions.

II.2 Preliminary Work

Previous efforts in this research project have been directed towards the identification and evaluation of potential preconditions for construction project success. This has been accomplished with an eye towards incorporating both the body of literature described earlier as well as the shared experiences

of a broad range of participants within the construction industry. For the most part, these early efforts have been subjective in nature.

Phase I of the study involved an exhaustive literature search and unstructured interviews with highly experienced managers within the construction industry in an attempt to identify all possible inputs to successful construction projects. Over 2000 different comments were obtained through these efforts. These comments were then categorized for further study into the 46 different factors in Figure 2.1.[9]

The ranks of the factors in the table are the result of subjective evaluations of the relative importance of each of the factors to achieving our definition of construction project success. Again, the experience of senior managers within the construction industry was tapped to obtain these evaluations. As depicted in the figure, both contractor and client personnel participated in this phase of the study. The rankings were determined by the algebraic mean of all ratings (using a five point scale) for each of the factors. The ratings for each class of respondent (contractor or owner) are depicted in the figure as well.

At this point in the study, all results were based on experience and opinion. While extremely valuable considering the cumulative experience of the participants, this information provided little specific evidence to support the assertions. Without factual data, the research would be of little value in guiding the actions and investment decisions of project

[9] Ashley, David B., Jaselskis, Edward J., and Lurie, Clive S., "The Determinants of Construction Project Success," (paper submitted for publication, The University of Texas, 1986).

OWNER AND CONTRACTOR FACTOR RATINGS

	FACTOR DESCRIPTION	MEAN RATING
1.	PROJECT MANAGER COMMITMENT	4.92
2.	PM CAPABILITIES/EXPERIENCE	4.83
3.	PLANNING EFFORTS	4.75
4.	PROJECT TEAM MOTIVATION	4.67
5.	SCOPE AND WORK DEFINITION	4.67
6.	PROJECT MANAGER INVOLVEMENT	4.50
7.	PROJECT OBJECTIVES	4.50
8.	CONTROL SYSTEMS	4.50
9.	SAFETY	4.50
10.	PROJECT MANAGER AUTHORITY	4.50
11.	PROJECT TEAM PARTICIPATION	4.50
12.	CLIENT GOAL ESTABLISHMENT	4.42
13.	PROJECT COST ESTIMATE	4.42
14.	CLIENT CONTACT'S AUTHORITY	4.25
15.	REGULAR MEETINGS	4.25
16.	REPORTING SYSTEMS	4.17
17.	CONSTRUCTION DRIVEN DESIGN	4.08
18.	PROJECT TEAM ATMOSPHERE	4.08
19.	INFORMAL RELATIONS	4.08
20.	PROJECT TEAM EXPERIENCE	4.00
21.	PROJECT TEAM MEMBER STABILITY	4.00
22.	PROJECT TEAM INVOLVEMENT	4.00
23.	DESIGN/INTERFACE MANAGEMENT	4.00
24.	TECHNICAL UNCERTAINTY	3.83
25.	RISK ID AND MANAGEMENT	3.83
26.	PROJECT TEAM REVIEWS	3.83
27.	COMMUNICATION RAPPORT	3.75
28.	PROJECT SELECTION PROCESS	3.75
29.	TECHNICAL INNOVATION	3.75
30.	ORGANIZATIONAL STRUCTURE	3.67
31.	STANDARD PROCEDURES	3.67
32.	LEGAL-POLITICAL ENVIRONMENT	3.58
33.	PROJECT TEAM ADAPTABILITY	3.50
34.	TASK FORCE DESIGN ENGINEERING	3.50
35.	PROJECT BIDDER QUALIFICATION	3.42
36.	PROJECT TEAM TRAINING	3.42
37.	LOCAL CONTRACTORS	3.17
38.	SUBCONTRACTING	3.08
39.	PUBLIC RELATIONS ENVIRONMENT	3.08
40.	CONTRACTOR CHANGE ADAPTATION	2.92
41.	PM SPATIAL DISTANCE	2.92
42.	CONTRACTOR PAST EXPERIENCE	2.75
43.	CONTRACTOR INVOLVEMENT	2.67
44.	PRIVATE VERSUS PUBLIC PROJECT	2.42
45.	PROJECT UNIQUENESS	2.33
46.	CONTRACTOR STRATEGIC CHANGE	2.33

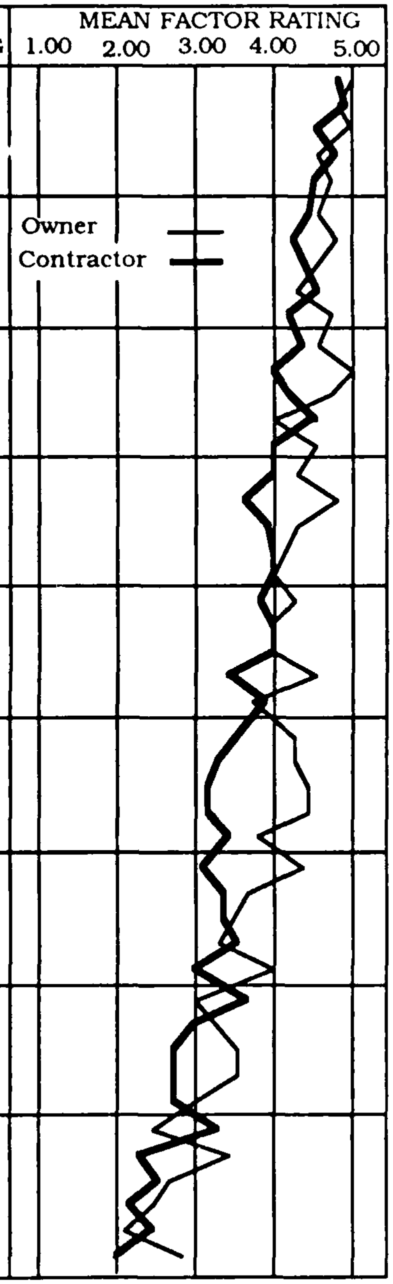


Figure 2.1: 46 Success Factors by Overall Rankings

management. In order to determine the feasibility of objectively evaluating the impact of factors on measurable success criteria, a pilot study was conducted using eleven selected factors from five factor categories and selected success criteria (Table 2.1).

The primary objective of the pilot study was to determine whether it was possible to rigorously evaluate success and the impact upon success of selected project inputs (factors). To accomplish this, it was necessary to gather actual data from several completed construction projects. Eight organizations, evenly divided between owner and contractor, participated in the study. Each organization provided information on two major construction projects in which they had actively participated. The companies were asked to include one average project and one highly successful project for the study, using their own evaluation criteria. Information was gathered using a structured interview with a senior person knowledgeable about the project. Objective as well as subjective information was obtained for each of the success criteria and the selected success factors.

Once obtained, the data was analyzed to determine whether statistically significant differences existed between both outcomes (success criteria) and inputs (factors) on projects categorized as average and those categorized as outstanding. Figure 2.2 depicts the differences between factors while Figure 2.3 represents the differences between success measures. The items in bold-face type represent those factors or success criteria which were determined to be statistically different between average and outstanding projects, using two-

SELECTED FACTORS BY CATEGORY AND SUCCESS CRITERIA FOR PILOT STUDY

RANK	MEAN RATING	FACTOR DESCRIPTION
		MANAGEMENT, ORGANIZATION AND COMMUNICATION
1.	4.92	Project Manager Goal Commitment
2.	4.83	Project Manager Capabilities and Experience
3.	4.67	Project Team Motivation and Goal Orientation
		SCOPE AND PLANNING
1.	4.75	Planning Efforts
2.	4.67	Scope and Work Definitions
3.	4.50	Project Objectives
		CONTROLS
1.	4.50	Control Systems
2.	4.50	Safety
3.	4.25	Regular Meetings
		ENVIRONMENTAL, ECONOMIC, SOCIAL AND POLITICAL
1.	3.83	Risk Identification and Management
2.	3.58	Legal-Political Environment
3.	3.08	Public Relations Environment
		TECHNICAL
1.	4.00	Design/Interface Management
2.	3.83	Technical Uncertainty
3.	3.75	Technical Advancement and Innovation
		SUCCESS CRITERIA
		Budget
		Schedule
		Client Satisfaction
		Functionality
		Project Team Satisfaction
		Contractor Satisfaction
		Follow-on Work
		Capabilities Build-up
		End User Satisfaction
		Specification

Table 2.1: Selected Factors by Category and Success Criteria for Pilot Study

FACTOR COMPARISON BETWEEN AVERAGE AND OUTSTANDING PROJECTS

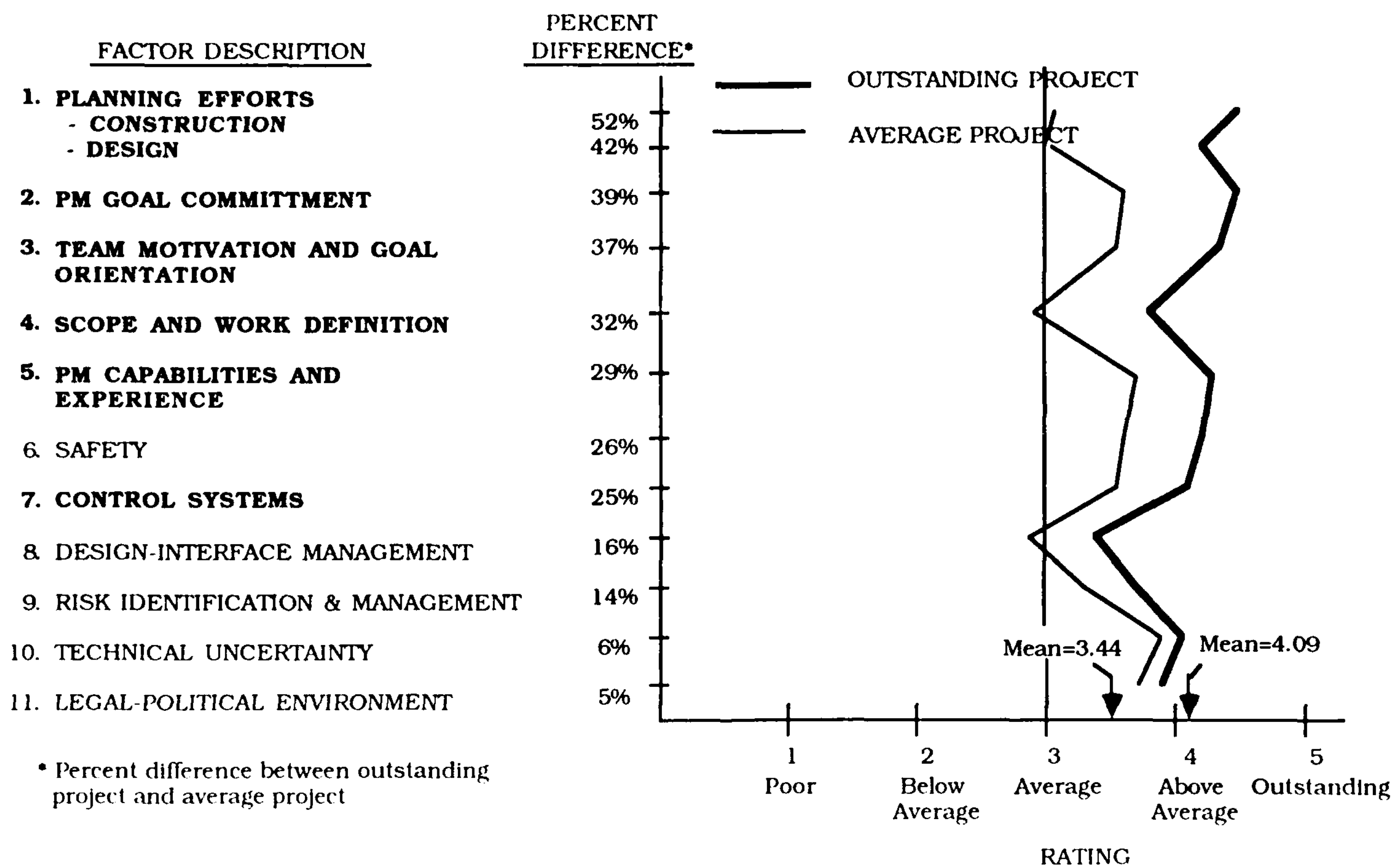


Figure 2.2: Factor Comparison Between Average and Outstanding Projects

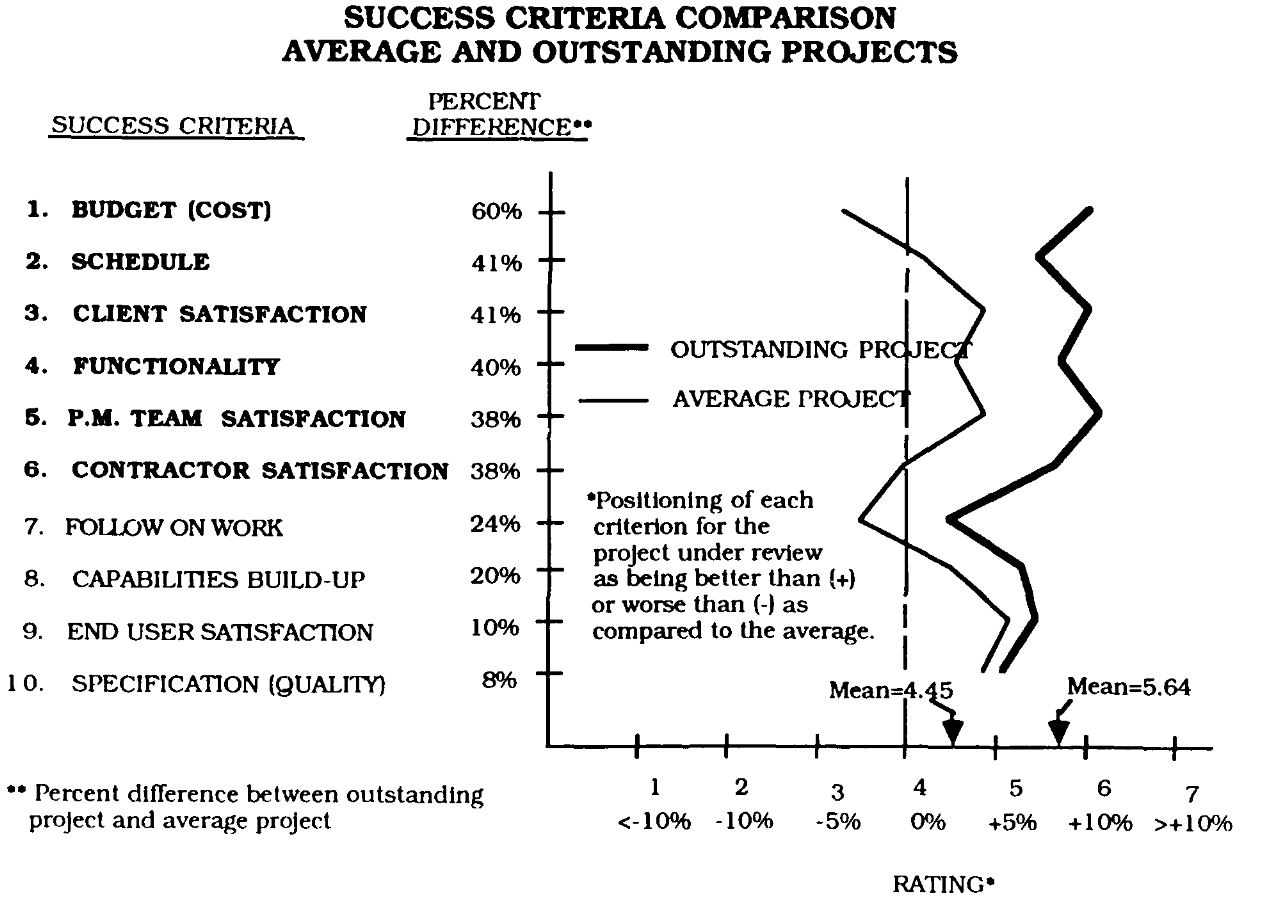


Figure 2.3: Success Criteria Comparison Between Average and Outstanding Projects

sample hypothesis testing which will be described in more detail later in this thesis.

The successful analysis achieved for the limited factors and projects included in the pilot study provide the impetus for the present work. Based on the preliminary results obtained it was decided to expand both the number of factors for investigation as well as the number of projects for study. Additionally, a much more rigorous analysis was sought in order to provide the background for what will eventually be a predictive model for successful construction projects. That effort and the results obtained are the subject of the remainder of this thesis.

II.3 Research Methodology

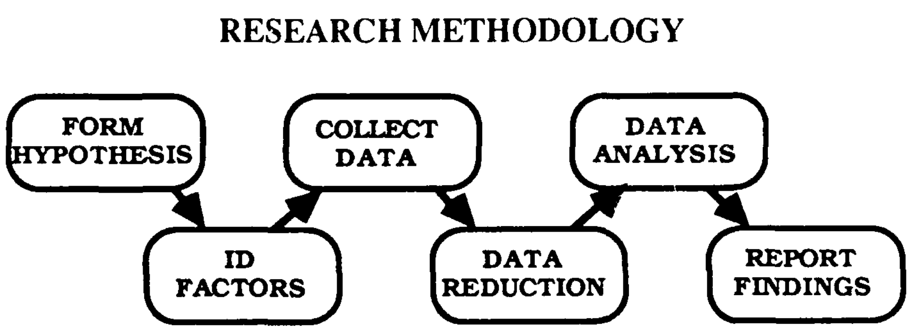


Figure 2.4: Research Methodology Flow Diagram

Figure 2.4 is a flow chart depicting the activities in this portion of the research. Step 1 is the establishment of the general hypotheses for analysis and testing in order to guide the data collection efforts. In general terms, we are attempting to establish the existence of causal relationships between certain

project inputs, or factors, and project outcomes, or success criteria. Additionally, we are attempting to establish a relationship between certain measures of project performance and the evaluation of the project as a successful one.

In order to provide manageable boundaries to our efforts, it was necessary to limit the factors for data collection and evaluation. The original list of 46 factors was felt to be too unwieldy for a single study of this nature. Additionally, it was felt that the rankings provided by the participants in the earlier phase of the research provided a valid means to identify those factors for which we could have a reasonable expectation of supporting our hypotheses. Further, we tried to generally limit the factors for evaluation to those which could be effected by management. In other words, we expended our efforts where positive findings could result in action recommendations for managers of construction projects. By combining some of the original 46 factors with others and applying the above criteria, 21 factors for detailed analysis were identified. These factors are described in Chapter III, Data Collection, of this thesis.

Identification of data requirements represented the next step in the research process. This presented one of the major challenges of the research, chiefly because the majority of the factors as identified could not be measured objectively in a direct fashion. Rather, it was necessary to identify the measurable components of each of the factors and then develop the comparison criteria for each component. To facilitate the statistical testing, it was desirable to identify components that could be measured quantitatively. In some cases, however, strictly quantitative components for a factor either did not exist or would have been impossible to obtain. An example in this

regard was the identification of the level of authority granted to the project manager for selection of project team members. Here it was necessary to identify levels of authority (unlimited, subject to veto, none, etc.) and then evaluate the project differences which corresponded to the different levels. In many cases, the available data was only an affirmative or negative response regarding the utilization of a particular management technique or procedure. These were evaluated in a similar manner. Appendix A depicts the data collection instrument which was utilized. The factors and selected measures for each are discussed in greater detail in Chapter III, Data Collection.

Following completion of the data collection efforts, data analysis began. The data were input into a microcomputer-based relational database for manipulation purposes. Selected information was then transferred to a statistical analysis microcomputer program for evaluation.

The statistical data analysis involved one-tailed statistical hypothesis testing to evaluate the differences between average and outstanding projects; between projects with budget performance above the sample median and those with budget performance below the sample median; and between projects with schedule performance above the sample median and projects with schedule performance below the sample median. For the various levels of the non-numerical data which were collected, the differences between budget and schedule performance for the project groups determined by the levels were analyzed. Table 2.2 depicts the data categories and the analysis which was performed.

DATA ANALYSIS BY CATEGORIES

Data Item	Classification	Analysis
Project Performance	Project Class (out, avg)	Performance difference between outstanding and average projects
Factor Data (Continuous)	Project Class (out, avg)	Factor difference between outstanding and average projects
	Budget Performance	Factor difference between projects with budget performance better than average and those with budget performance worse than average
	Schedule Performance	Factor difference between projects with schedule performance better than average and those with schedule performance worse than average
Budget Performance	Factor Data (Discrete)	Difference in budget performance between projects grouped according to levels of discrete data
Schedule Performance	Factor Data (Discrete)	Difference in schedule performance between projects grouped according to levels of discrete data

Table 2.2: Data Analysis Categories

The statistical test was used to determine the certainty with which we could establish the existence of a difference between the means of the various factors and outcomes. For each analysis category described in Table 2.2, a null hypothesis was established which stated that the difference between the sample means for the particular test category equaled zero. An alternative hypothesis was selected based on our expectations of the algebraic sign (difference greater than or less than zero) of the difference between the sample means. The microcomputer program used the sample sizes, means, variances and data points to determine the probability of making an error by rejecting the null hypothesis (sample mean differences equal to zero). This probability, known as the significance level, provides us with a measure of the certainty with which we can assert that differences exist between the sample categories.[10]

For our analysis, we intend to accept the existence of differences between groups if the significance level of the differences is less than or equal to .15. For instance, we intend to evaluate the existence of a difference between average and outstanding projects in terms of performance against the original budget. If the analysis determines the significance level of the difference between budget performance for the two categories of projects to be less than or equal to .15, we accept that as evidence that the mean of budget performance for <u>all</u> average projects is different from the mean of budget performance for <u>all</u> outstanding projects.

[10]This brief treatment of statistical hypothesis testing comes from William Mendenhall and James E. Reinmuth, <u>Statistics for Management and Economics, Fourth Edition</u> (Boston, Massachusetts: Duxbury Press, 1982), pp. 283-289 which the interested reader may consult for a more detailed treatment.

CHAPTER III

DATA COLLECTION

III.1 Data Requirements

The data collection process was conducted during the spring, summer, and fall of 1986. The initial step was the selection and definition of the 21 factors for analysis. Following identification of the factors, each was analyzed to determine appropriate measures for them.

Several considerations guided the determination of factor measures. Most significant was the desire to perform as rigorous a study as possible. This required the identification wherever possible of numerical measures for factors. Considering the broad range of project scopes we expected to encounter, normalization was also a key concern. In addition, the broad range of respondent classifications required the identification of criteria which would have similar meaning across that range. Finally, we did not hope to fully describe the nature of each factor for each project. Rather, measures were selected which were felt to be key proponents of a particular factor and were also expected to be reasonably available.

Appendix A is the data sheet which was completed for each project in the study. A definition of each of the 21 factors and a description of the selected measures follows:

III.1.1 Project Manager

Project Manager Involvement and Commitment: The project manager's early and continued involvement with the project and the level of that involvement. Measurements include the point on the project timeline when the project manager was assigned; the number of project levels from the project manager to the crafts; the number of projects managed by the project manager during project execution; the portion of the project manager's work time devoted to the project; and the existence and size of any personal incentives for the project manager related to the project.

Project Manager Authority and Influence: The project manager's level of authority with regard to project team selection, contractor selection, budget, project design and changes thereto, and project controls. Each project is categorized into one of four authority levels in each of the particular areas. Additionally, any monetary limits upon the change order approval authority of the project manager are documented.

Project Manager Capabilities and Experience: The project manager's educational background, project management experience on similar size and type of projects, and other construction experience. Measurements include highest education level achieved; education type; number of similar projects in terms of scope and technology as project manager and as other than project manager; and years of experience as a project manger and in other construction capacities.

III.1.2 Project Team

Project Team Capabilities and Experience: The experience of the different parties making up the project team (owner, constructor, designer) with projects of a similar or larger size and with projects of a similar technology. The experience of each organization was categorized as high, medium, low, or none.

Project Team Motivation: The level of motivation of the different parties making up the project team. This is evaluated by determining the nature of the contractual relationships between the parties and by determining the existence and size of contractual incentives or penalties.

Project Team Stability: The degree of change among project personnel throughout the project life. This is determined by the rate with which personnel turnover occurred for management and for the entire work force.

Project Team Orientation: The nature of the relationship between and within the different project parties with respect to the degree of teamwork which exists. Evaluated according to the existence or lack thereof of previous project relationships between the various parties, the use of a single contractor for design and construction, the use of the same individual team members from a previous project, and the amount of work performed by subcontract.

Project Safety: The project safety program and results thereof. This is measured by the budget percentage devoted to safety, the frequency of safety inspections, the amount of

individual safety training, the existence of safety records, and the project's safety performance record.

III.1.3 Planning

Design: The investment in and effectiveness of the design effort. This is measured by the budget percentage devoted to the design effort, the percentage of construction manhours devoted to engineering rework, and the cost of project changes as a percent of the total project cost.

Scope Definition: The degree and timing of project scope definition. This is evaluated by the percentage of the detailed design completed by the start of construction, the percentage of the total project duration completed prior to the start of construction, and the cost of project changes as a percent of the total project cost.

Cost Estimate: The accuracy of the project estimate effort, as determined by the accuracy of the estimates of productivity, labor wage rates, and material costs.

Constructability: The degree to which specific procedures were utilized to enhance the ease with which the facility is constructed. This is measured by the degree of modularization, the existence of an in-process review of the design by the construction organization, and the existence and nature of a constructability program (formal, informal).

Risk Identification and Management: The evaluation and management of risks associated with project execution. This is measured by the nature of the risk identification process

(formal versus informal), the budget percentage devoted to contingency, and the percentage of the budgeted contingency which is actually used.

Preplanning: The amount and extent of planning efforts compieted prior to project execution. This is measured by the percentage of total project manhours devoted to preconstruction activities and the number of different project execution areas addressed in a project execution plan.

III.1.4 Controls

Control Systems: The methods and techniques to control all aspects related to project execution. Measurement areas include the type of schedule control techniques used; frequency of cost control data collection and reporting; the percentage of the construction cost devoted to construction management; the frequency of formal inspections in the areas of progress, quality, and safety; the percentage of the total project cost devoted to control systems; the frequency of control meetings; and the frequency with which control budgets and schedules are updated to reflect changing conditions.

Communications: The existence and utilization of effective communication channels among the different project parties. This is evaluated by the relative locations of the owner team and the contractor team, the use of liaison personnel, the location of key project personnel (managers) relative to the site, the existence of strictly defined communication channels

on project organization charts, and the primary communication mode.

Design Interface Management: The management of the interface between different design disciplines, evaluated by the frequency of design team meetings and the number of design reviews for each drawing.

Standard Operating Procedures: The extent to which project execution is affected by the existence of standard procedures. This is evaluated by the number of project management areas governed by existing standard operating procedures.

III.1.5 Other Factors

Owner Authority and Influence: The degree to which the owner's project manager or principal contact wields authority over project execution. Evaluation areas include the contact's change approval limit, the time required for approval of changes, the percentage of total materials supplied by the owner, and the extent to which the owner withheld approval authority over contractor personnel and subcontractor selection.

Owner Goals: The extent to which project objectives are clearly specified to contractors by the owner organization. This is evaluated by the number of project performance areas for which a clearly stated objective exists.

Technical Uncertainty and Complexity: The level of complexity of the project and the experience of the project

team with similar technology. Each project is categorized according to the level of experience of the project team with the specific technology and the relative complexity of this project in terms of construction methods, process complexity (for process plants), and quality requirements.

III.2 Data Collection Process

Coincident with the identification of specific data requirements was the identification of target organizations for inclusion in the research. A target population of ten contractors and ten owners was established. Previous relationships established in the earlier research were maintained. Six additional contractor and owner organizations were solicited for participation in the study. The introduction to the research for all members of the target population was accomplished by correspondence in June 1986. This was followed shortly thereafter by telephonic contact for the purpose of initiating the data collection efforts.

The actual data collection process varied according to respondent company. In most cases an initial information briefing was presented to the organization's contact for the purpose of communicating the nature of the research and the data requirements. Respondent companies were asked to provide project records, final reports, and execution plans for review by a researcher prior to interviews with key project personnel. These records were either provided at the initial meeting or were provided shortly thereafter by correspondence. In some cases, companies provided project records based solely on the initial telephonic contact,

precluding the requirement for an information briefing. Following this review, a follow-up interview was arranged to complete the data collection.

Significant deviations from the above pattern did occur. Some organizations were not as comfortable about distributing copies of project records and required review of the records at their offices. In these cases, interviews were scheduled at a later time during the same visit. In the case of two organizations, the project data sheets were completed by company personnel after receiving an orientation from a researcher.

III.3 Data Summary

Thirteen of the original twenty target companies participated in the study. Of these thirteen, six were owner organizations and seven were contractor organizations. Each participant provided one average and one outstanding project for inclusion in the research with the exception of one owner organization, which provided an additional outstanding project, and one contractor organization, which did not provide an average project. Of the twenty-six total projects, fourteen were classified as outstanding and twelve were classified as average. Total project costs ranged from a high of over $2 billion to a low of approximately $10 million. Total project durations ranged from a high of 73 months to a low of 21 months. A majority of the projects studied had some relationship to chemical processing. Table 3.1 summarizes the major project characteristics.

CHARACTERISTICS OF PROJECT SAMPLE

VARIABLE DESCRIPTION	SAMPLE CHARACTERISTICS		
	AVG	OUT	TOTAL
	(N=12)	(N=14)	(N=26)
COMPANY AND PROJECT UNDER REVIEW			
Contractor Companies	50%	50%	50%
Owner Companies	50%	50%	50%
COMPANY FUNCTIONS			
Engineering	25%	14%	19%
Engineering/Construction	8%	22%	15%
Construction	17%	14%	16%
Owner	50%	50%	50%
RESPONDENTS INDIVIDUAL ROLE			
Project Manager	67%	43%	54%
Construction Manager	8%	7%	8%
Project Engineer	8%	36%	23%
Other	17%	14%	15%
PROJECT LOCATION			
Domestic	92%	71%	81%
International	8%	29%	19%
CONSTRUCTION INDUSTRY BRANCH			
Industrial	75%	86%	81%
Commercial	8%	14%	11%
Civil	17%	0%	8%
TECHNOLOGY TYPE			
Process Plant	66%	57%	62%
Resource Recovery	0%	14%	8%
Civil	17%	7%	11%
Other	17%	22%	19%
NATURE OF CONTRACT OR AGREEMENT			
Fixed Price	8%	21%	15%
Reimbursable Cost - Fixed Fee	25%	43%	35%
Reimbursable Cost - Percentage Fee	42%	14%	27%
Unit Price	8%	8%	8%
Owner In-house	17%	14%	15%
PROJECT COST ($mil)			
Mean	80.7	255.8	175.0
PROJECT DURATION (mos)			
Mean	34	45	40

Table 3.1: Characteristics Of Project Sample

III.4 Analysis of Data Collection

The data collection effort undertaken was an extremely ambitious one for the period allotted for the study. The biggest challenge was the attempt to objectively capture the essence of each of the evaluated factors on a particular project. Evaluation required the development of generic terminology for the issues under study. The thirteen organizations under study had at least thirteen different ways of executing construction projects. Even the term "project manager" was not universal in meaning. As a result, great care was required to insure "apples to apples" comparisons. Particular difficulties encountered in data collection and analysis are described in the following paragraphs.

III.4.1 Project Classification and Characteristics

The primary difficulty encountered here resulted from the limited knowledge of the total project on the part of construction contractor respondents, particularly in the case of those respondents performing lump sum work using completed designs. As a result, information regarding total project cost or duration was not available. However, this is not particularly significant for our study because it was still possible to obtain relative cost and schedule information for use as a measure of project performance for this class of respondent.

A more significant issue related to project performance data is the lack of objective measurements for a variety of potential success criteria. As a result, the impact of subjective project outcomes such as client satisfaction, team satisfaction,

follow-on work, and capabilities build-up upon the classification of a project as a successful one cannot be statistically evaluated. Additionally, surprisingly little objective data was available regarding the technical performance of the completed projects, resulting in an inability to evaluate this as well.

III.4.2 Project Manager

The most difficult issue in this area was the definition of project manger. This issue was clouded by the various job titles and descriptions for project directors, project engineers, construction managers, design managers, and contract administrators. This issue was usually resolved during an interview with the researcher.

Several items of information regarding project managers proved to be non-discriminatory. All organizations seemed to assign project managers to the project at the earliest possible time, usually at inception. Not one of the organizations studied provided incentives to project managers tied directly to the performance of the project they were working on. Finally, only a minimal number of project managers had clearly defined monetary limits to their ability to approve changes for their organization or their authority to shift funds between budget items. As a result, differences in authority level can only be determined based on the classifications determined jointly by the respondent and the researcher.

III.4.3 Project Team

Initial efforts were directed at identifying the type and quantity of the individual skills included on the project team, as well as the experience level of the individuals in those positions. It became apparent early in the study that research in that regard could rightly qualify as a separate, equal research project to the one being undertaken. Additionally, the comparison and terminology difficulties alluded to earlier were compounded. As a result, this effort was abandoned and evaluation of project team capabilities and experience was based on consideration of the experience of the participant organizations in the particular industry and on similar size projects.

Project team motivation is largely a subjective issue. However, we approached the problem from the standpoint of factors which could impact organizational motivation. This would allow us to address management actions with regard to motivation-related issues. Our evaluation was based upon a consideration of the use of contractual incentives and penalties and the nature of the contractual relationships. Although we were able to evaluate the existence of contractual penalties or incentives, we were not successful in identifying comparable amounts where they existed, chiefly because of the various means used to determine these amounts.

A similarly largely subjective issue was that of project team orientation. Our approach in this regard was an evaluation of the existence of previous contractual relationships between some or all of the parties involved. While this does not directly measure informal relationships between organizations and

members or the type of leadership style utilized (authoritarian versus participative), it does indicate the familiarity which exists among the parties. Additionally, considering that most of the projects involved limited bid lists, the existence of previous contractual relationships is strongly indicative of the existence of previously good working relationships.

Two other particular data items within the project team category were not available or too difficult to obtain from a sufficient number of respondents to allow analysis. Workforce turnover rates were not available in most cases, most often due to the large amount of lump sum subcontracting employed by the construction organizations. Also not generally available was the portion of the budget devoted to safety and safety programs. Although limited, sufficient safety performance information was gathered to allow analysis of this area.

III.4.4 Planning

Most of the data requirements within this category were readily obtainable. In some cases, responses total less than twenty-six because of the lack of specific design information available from construction contractors. Surprisingly, some difficulty was encountered in obtaining information regarding rework. Additionally, in cases where modularization was used, it was difficult to determine what portion of the project was accomplished by this method. This resulted in the inclusion in the data base of informed estimates for both of these values in some instances.

III.4.5 Controls

Data in this category was also generally available. However, from the standpoint of evaluating management investments, the data collection results were disappointing due to the extremely limited success in isolating costs related to project controls and to construction management. The only other notable issue in this category was the limited discrimination found between projects with regard to control meetings, which were generally found to occur on a weekly basis.

III.4.6 Other Factors

Owner authority and influence could not be adequately evaluated in an objective manner. Extremely limited information was available regarding the monetary limits of authority of the owner's principal contact. Also, owner authority regarding contractor personnel and subcontractor selection was almost universally similar, hence no differentiation existed for comparison.

Technical uncertainty and complexity could not be evaluated in strictly numerical terms. Projects were classified according to relative levels of complexity based on discussions between respondent and researcher.

CHAPTER IV

DATA ANALYSIS

IV.1 Project Performance

Project performance was evaluated using a wide variety of measures related to engineering and construction schedules and costs. Table 4.1 depicts those measures which exhibited significant differences between average and outstanding projects in terms of cost and schedule performance using our criteria of .15 as the maximum acceptable error probability. Figure 4.1 is a graphical representation of the tabular results.

PERFORMANCE DIFFERENCES
AVERAGE VERSUS OUTSTANDING PROJECTS

Null Hypothesis: The mean of *project performance measures* for outstanding projects is equal to the mean of *project performance measures* for average projects.

Alternate Hypothesis: The mean of *project performance measures* for outstanding projects is less than the mean of *project performance measures* for average projects.

PERFORMANCE MEASURE	OUTSTANDING PROJECTS	AVERAGE PROJECTS	% DIFF FROM AVG	SIG LEVEL
Project Budget	-8.2%	4.4%	-12.0%	.001
Construction Schedule	0.5%	12.7%	-10.8%	.005
EPC Schedule	-1.6%	10.6%	-11.0%	.011
Lost Time Rate	2.2%	5.5%	-51.1%	.056

Table 4.1: Performance Differences Between Average and Outstanding Projects

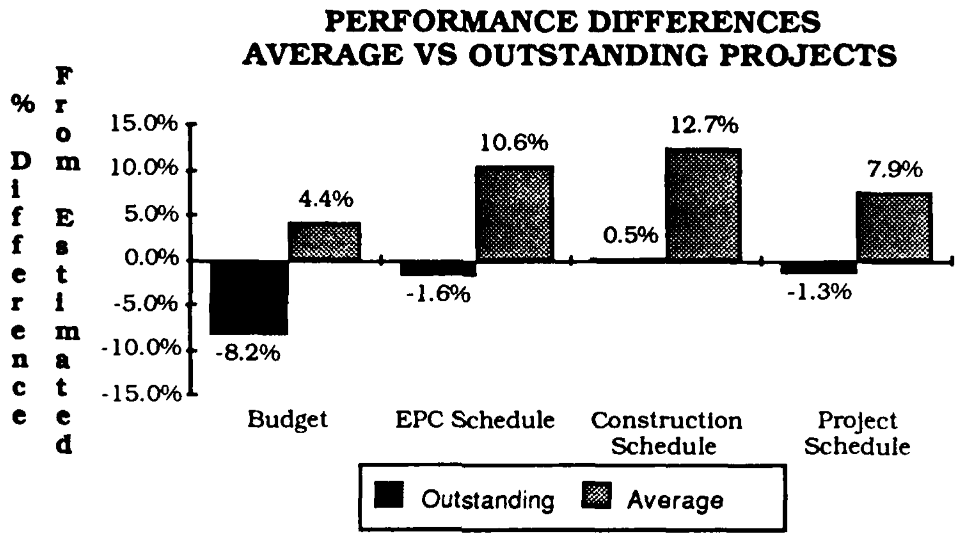


Figure 4.1: Performance Differences Between Average and Outstanding Projects

The significance level shown in the table represents the probability of an error if we accept the hypothesis that the difference between project groups exists as stated. In other words, if we accept that project budget performance differs between average and outstanding projects, a .1% possibility exists that we are wrong.

For each project performance measure in the table, we have also indicated the level of the performance measure for both categories of projects (average and outstanding) as well as the percentage difference from the average demonstrated by outstanding projects. As noted in the table, outstanding projects displayed sizable, significant differences from average projects for budget performance against the control budget, construction schedule performance, and project (engineering, procurement, construction) schedule performance. Clearly,

cost and schedule performance <u>are</u> significant determinants of construction project success.

Safety performance of the projects in terms of the project lost time rate also exhibited a significant difference between average and outstanding projects. This outcome indicates one of two possibilities regarding project safety performance. Project safety performance may in fact be a criteria for classification of a project as outstanding. Alternately, project safety performance may impact upon project budget and schedule performance, thereby affecting the classification of the project. This possible relationship between safety performance and project performance measures will be evaluated later in this thesis.

Significant in its absence from Table 4.1 is the difference between average and outstanding projects in terms of engineering schedule performance. In fact, engineering performance against schedule was actually poorer on the outstanding projects, although the difference was not statistically significant. Although not conclusive, the results seem to indicate that engineering performance against the engineering schedule does not play a significant role in determining whether a project is perceived as successful. An alternate but equally likely conclusion is that engineering performance against schedule is not a precondition for a successful project outcome.

As discussed in the data collection analysis, limited technical performance data was collected. The lack of available data itself may indicate the relative importance of this project outcome as a measure of construction project success. Despite

the numerous articles which assume that the technical performance of a construction project is an important consideration in classification of a project as successful, technical performance measurement was not apparent. This causes us to suspect that it is not an important characteristic that distinguishes the truly outstanding projects from the merely average ones.

Another performance characteristic that did not demonstrate a statistically significant difference between average and outstanding projects was the performance against estimated construction labor requirements. Again, although we cannot say that a difference does not exist, the difference is clearly not as significant as those in cost and schedule performance.

The aggregate findings regarding project performance possibly indicate that cost and schedule are still the bottom line. How you achieve positive results in those areas does not appear to distinguish average from outstanding.

IV.2 Project Characteristic Differences

Table 4.2 and Figure 4.2 depict the significant differences between project characteristics (location, total cost, duration, size). Significant differences occur for project length and project labor requirements between average and outstanding projects. Perhaps surprisingly, the larger projects in terms of duration and manpower were judged to be more successful than the smaller projects. This may be the result of

more favorable impressions of a larger project with similar

PROJECT CHARACTERISTIC DIFFERENCES

AVERAGE VERSUS OUTSTANDING PROJECTS

Null Hypothesis: The mean of *project characteristic measures* for outstanding projects is equal to the mean of *project characteristic measures* for average projects.

Alternate Hypothesis: The mean of *project characteristic measures* for outstanding projects is greater than the mean of *project characteristic measures* for average projects.

PERFORMANCE MEASURE	OUTSTANDING PROJECTS	AVERAGE PROJECTS	% DIFF FROM AVG	SIG LEVEL
Project Duration (mos)	44.7	34.2	30.8%	.026
Constr Duration (mos)	29.9	23.4	27.5%	.059
Total Manhours (1000)	15776.3	2120.4	644.0%	.128
Peak Labor (men)	1603.2	587.9	172.7%	.132

Table 4.2: Project Characteristic Differences Between Average and Outstanding Projects

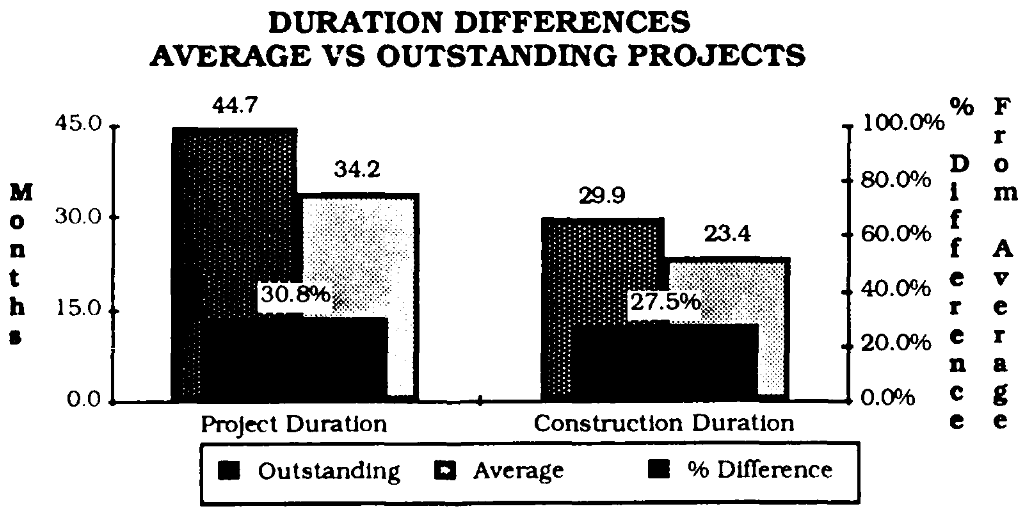


Figure 4.2: Duration Differences Between Average and Outstanding Projects

performance characteristics of a smaller project because of the perception that larger projects pose greater challenges. Although this does not have any significant implications for project managers, it does appear to indicate that project size is not a significant deterrent to achieving project success.

IV.3 Factor Differences Between Classes

Significant differences for project inputs between outstanding and average projects are depicted in tabular form in Table 4.3. Figure 4.3 is a graphical representation of those significant factors measured with absolute values while Figure 4.4 depicts those measured using normalized values or ratios.

Significant differences existed for some project manager characteristics between project classes. A deeper project hierarchy existed between project managers and crafts on outstanding projects than on average projects. This appears to be directly related to the earlier findings regarding project size. Project managers on outstanding projects also had more project management experience and more total construction experience than those on average projects. However, the type of experience in terms of similar size projects or similar construction technology did not reflect similar differences. This indicates that previous experience as a project manager and in other positions on construction projects, regardless of the sizes or types of projects on which that experience was gained, is an important characteristic of successful project managers. Considered in light of the lack of a significant difference between the portion of their time that project managers for average projects and those for outstanding projects devoted to

their respective projects, it appears that the "Work Smarter, Not Harder" axiom applies to successful project management.

FACTOR DIFFERENCES

AVERAGE VERSUS OUTSTANDING PROJECTS

Null Hypothesis: The mean of *factor measures* for outstanding projects is equal to the mean of *factor measures* for average projects.

Alternate Hypothesis: The mean of *factor measures* for outstanding projects is greater than (or less than) the mean of *factor measures* for average projects.

PERFORMANCE MEASURE	OUTSTANDING PROJECTS	AVERAGE PROJECTS	% DIFF FROM AVG	SIG LEVEL
PROJECT MANAGER				
Project Levels	5.6	5.1	11.0%	.108
Project Mgmt Exp (# projects)	15.7	11.5	36.8%	.125
Total Project Exp (years)	25.8	21.5	19.8%	.132
PROJECT TEAM				
Team Turnover (%/mo)	8.5%	18.2%	-53.3%	.055
Lost Time Rate	2.2	5.5	-51.1%	.056
PLANNING				
Contingency Used (% budg)	29.0%	78.2%	-63.0%	.002
Modularization (% cost)	7.3%	1.3%	451.0%	.052
Changes (% cost)	5.5%	8.7%	-36.0%	.104
Productivity Estimate Error	8.0%	-5.0%	260.0%	.130
PROJECT CONTROLS				
Control System Cost (% cost)	1.4%	0.7%	95.2%	.109
Budget Update Frequency (#/yr)	8.9	6.5	37.8%	.133

Table 4.3: Factor Differences Between Average and Outstanding Projects

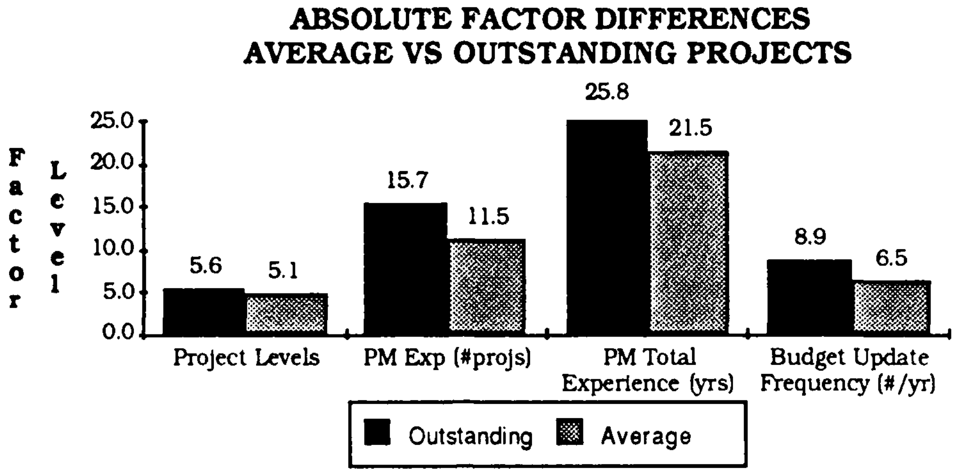


Figure 4.3: Absolute Factor Differences Between Average and Outstanding Projects

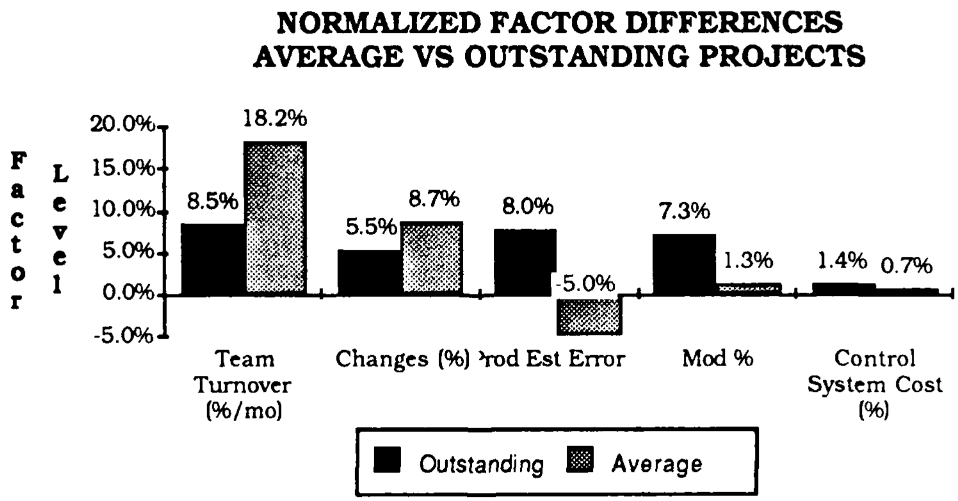


Figure 4.4: Normalized Factor Differences Between Average and Outstanding Projects

Factor measures related to the Project Team which displayed significant differences between average and outstanding projects included team turnover and project lost

time rate (as discussed earlier). The relationship between team turnover and project classification may be similar to the relationship of project lost time rate. Projects may be perceived as outstanding because the lack of personnel turnover left the impression that everything related to the project operated in a smoother fashion. More likely, team turnover may be a factor in determining the performance of the project against budget and schedule, thereby influencing the eventual categorization of the project.

Average projects used more of their budgeted contingency than outstanding projects. This use of contingency is contrary to the view of some of the participants in the study who felt that execution of the project according to the plan was a significant criterion in the classification of a project as successful. If a well-planned project includes a careful determination of contingency as we would expect it to, the most successful projects should use a major portion of that contingency to support that theory. On the contrary, these results support earlier findings that performance against budget is a significant criteria for successful projects due to the close relationship between performance against budget and the use of contingency funds.

Perhaps surprisingly, the outstanding projects had less accurate estimates of construction productivity than the average ones. The outstanding projects performed better than expected in terms of productivity, while the average projects performed worse than expected, although the difference from expected was not as great on the average projects. Considering the effect of better productivity on cost and schedule, we have further evidence to suggest that performances against cost and

schedule are key criteria in classification of projects as successful.

Average projects also experienced more changes than outstanding projects. It appears to be a fact of construction project management that most changes cost money as opposed to saving money. Consequently, more changes imply worse performance against budget and an evaluation as a less successful project. Alternately, changes may play a role similar to team turnover in determining the classification of a project as successful. Fewer changes may leave the impression on the part of the evaluator that the project was smoother and consequently more successful.

Outstanding projects had more modularization than average projects. If budget and schedule are the criteria for successful projects as our findings suggest, the most likely explanation for this relationship is the positive effect that modularization should have on budget and schedule.

Most data in the Controls factor category exhibited results similar to what was expected. Significant differences were found between average and outstanding projects for the cost of control systems and the frequency of budget updates. Both of these factors represent measures of the extent of control systems for the projects and indicate that greater controls can be a significant factor in achieving successful outcomes. On the other hand, significant differences between the extent of standard operating procedures on average and outstanding projects did not exist for our project sample.

It is important to note that all measures of project manager authority for which we were able to obtain data were of

a discrete categorical nature (e.g., unlimited, some, limited). For this reason, we were unable to statistically evaluate the effect of this particular factor upon construction project success. Project Team measures in the areas of motivation, capabilities and experience, and team orientation experienced similar data limitations, as did communications within the Controls category and technical uncertainty within the Other Factors category. Therefore, we cannot comment upon the differences between average and outstanding projects in terms of these attributes. Differences between both project budget and project schedule performance (key success criteria) for projects with varying levels of these and other discrete factor data items are evaluated in the remaining sections of this chapter.

IV.4 Schedule Performance

IV.4.1 Factors Which Cause Schedule Differences

We have proposed several possible hypotheses related to the relationship between various factors, schedule performance, budget performance, and project classification. Also, the differences between project classes for a large portion of the data collected could not be statistically evaluated due to the nature of that data. For this reason, we have elected to perform separate analyses using project schedule performance and project budget performance as classification factors for both our continuous factor data and our discrete factor variables. From this, we hope to answer some of the questions raised in the

earlier sections of this chapter. Additionally, we hope to identify specific management actions for specific project objectives.

The factors and corresponding levels for which project performance against schedule was significantly different are depicted in tabular form in Table 4.4 and graphically in Figures 4.5 and 4.6. Surprisingly, projects performed better against the schedule when the project manager was given less authority. A plausible explanation for this is that the lack of authority regarding budget, design, or controls also represents a lack of responsibility for that area, freeing the project manager for other activities. This hypothesis is further supported by the deterioration in project schedule performance for projects where the project manager remained in the organization's home office where he may be more likely to be responsible for the authority areas described and less closely involved with execution matters. In any event, the nature of this finding indicates more research is required.

Different levels of Project Team technical experience resulted in significant differences in project schedule performance. Those projects with a high level of experience with similar technology on the part of any participant performed better against schedule than other projects. However, similar differences were not found when projects were categorized according to the participants scope experience, indicating that previous experience with projects of a similar technology is more important than previous experience with projects of a similar or larger size in achieving better schedule performance. These findings are supported by the impact of project technical complexity in terms of

temperature and quality requirements on schedule performance. The more complex the projects, the poorer the performance against schedule.

SCHEDULE PERFORMANCE DIFFERENCES BASED ON FACTOR MEASURE LEVELS

Null Hypothesis: The difference between the mean of the *schedule difference from estimated* for high or positive factor levels and the mean of the *schedule difference from estimated* for low or negative factor levels is equal to zero (no difference).

Alternate Hypothesis: The difference between the mean of the *schedule difference from estimated* for high or positive factor levels and the mean of the *schedule difference from estimated* for low or negative factor levels is less than (or greater than) zero.

	SCHEDULE PERFORMANCE			
FACTOR MEASURE	BETTER LEVEL	LOWER LEVEL	% DIFF FROM LOWER	SIGN LEVEL
PROJECT MANAGER				
Location (site/home)	-3.5%	8.2%	-10.8%	.006
Controls Authority (low/high)	-1.5%	6.0%	-7.1%	.060
Budget Authority (low/high)	-4.7%	4.2%	-8.5%	.092
Design Authority (low/high)	-3.9%	4.0%	-7.6%	.119
PROJECT TEAM				
Designer Tech Exp (high/low)	-0.2%	12.1%	-11.0%	.012
Constructor Tech Exp (high/low)	-1.3%	9.4%	-9.8%	.013
Owner Tech Exp (high/low)	-0.4%	6.6%	-6.6%	.073
PROJECT CONTROLS				
Teams Co-located (yes/no)	1.1%	7.5%	-6.0%	.119
OTHER FACTORS				
Quality Complexity (low/high)	-0.9%	7.2%	-7.6%	.044
Temp Complexity (low/high)	-1.4%	9.5%	-10.0%	.110

Table 4.4: Differences in Schedule Performance Based on Factor Measure Levels

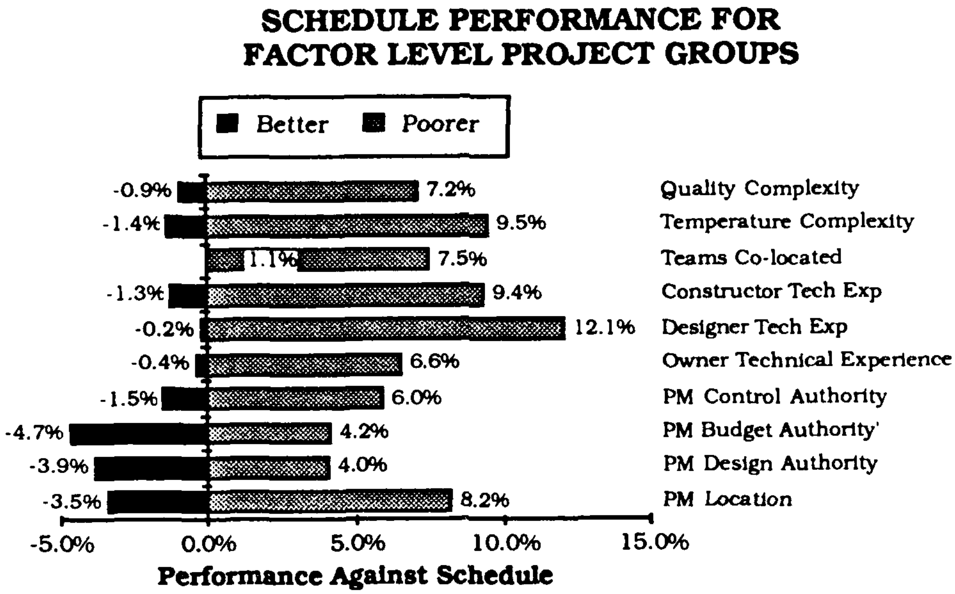


Figure 4.5: Schedule Performance Levels For Different Factor Levels

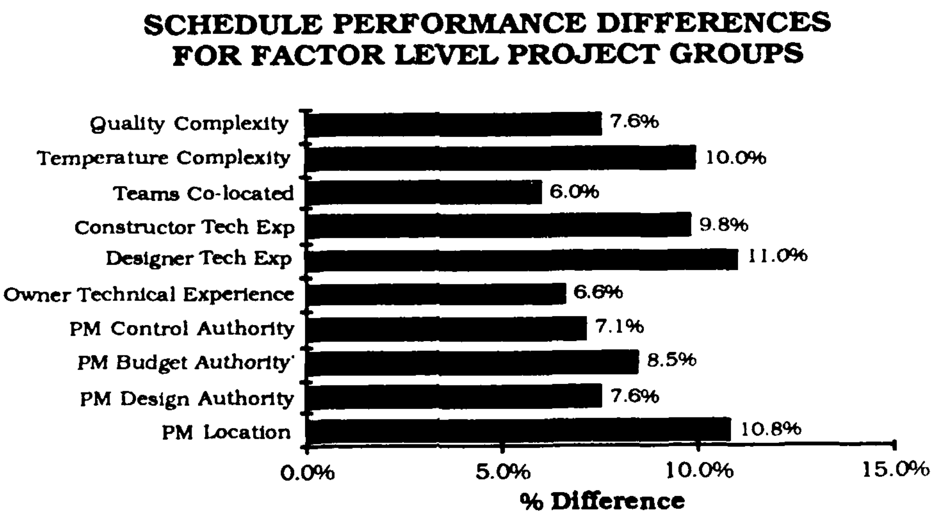


Figure 4.6: Schedule Performance Differences For Different Factor Levels

IV.4.2 Factor Differences Between Schedule Performance Groups

Table 4.5 uses an alternate viewpoint to determine whether a relationship exists between continuous factor data items and the level of schedule performance. Projects were divided into two equal groups based on the level of schedule performance. Continuous factor data was then evaluated to determine statistically significant differences between these groups.

The two project groups were similar to those determined earlier by project class. 86% of projects with schedule performance better than or as good as the median project were classified as outstanding. On the other hand, 83% of projects with schedule performance worse than or equal to the median were classified as average. As a result of this similarity, the findings approximate earlier findings based on the differences between project class. The results are depicted graphically in Figures 4.7 and 4.8.

Project managers who devoted a greater percentage of their time to their projects participated in projects with better performance against schedule. This supports our earlier finding regarding the impact of the project managers location on schedule performance. In both cases, greater involvement with the project correlated with better performance against schedule.

Findings regarding lost time rate, modularization, and use of contingency support earlier hypotheses regarding the relationship of these factors, schedule performance, and project classification. The relationships between lost time rate

and schedule performance and modularization and schedule performance are easy to comprehend. It appears from these findings that the differences in these data items between average and outstanding projects are based on their close relationship to schedule performance, which appears to be a strong criterion for a successful project.

FACTOR DIFFERENCES BASED ON SCHEDULE PERFORMANCE LEVELS

Null Hypothesis: The difference between the mean of the *factor levels* for projects with performance against schedule better than the median and the mean of the *factor levels* for projects with performance against schedule worse than the median is equal to zero (no difference).

Alternate Hypothesis: The difference between the mean of the *factor levels* for projects with performance against schedule betrer than the median and the mean of the *factor levels* for projects with performance against schedule worse than the median is greater than (or less than) zero.

FACTOR MEASURE	SCHEDULE PERFORMANCE BETTER	SCHEDULE PERFORMANCE WORSE	% DIFF FROM POORER	SIG LEVEL
PROJECT MANAGER				
Time Devoted to Project (%)	86.6%	71.0%	22.0%	.119
PROJECT TEAM				
Lost Time Rate	1.9	5.0	-61.6%	.094
PLANNING				
Modularization (% cost)	6.0%	1.4%	319.6%	.059
Contingency Used (% budg)	40.6%	61.2%	-33.8%	.100
PROJECT CONTROLS				
Safety Inspection Freq (#/wk)	2.1	3.6	-42.8%	.021
Quality Inspection Freq (#/wk)	3.8	4.6	-17.2%	.092

Table 4.5: Differences in Factor Levels Based on Schedule Performance

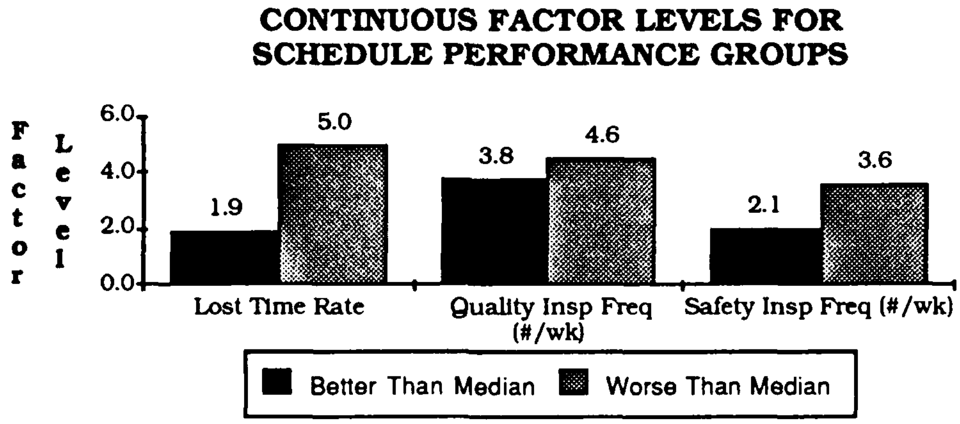


Figure 4.7: Levels of Continuous Factor Data For Projects Grouped According to Schedule Performance

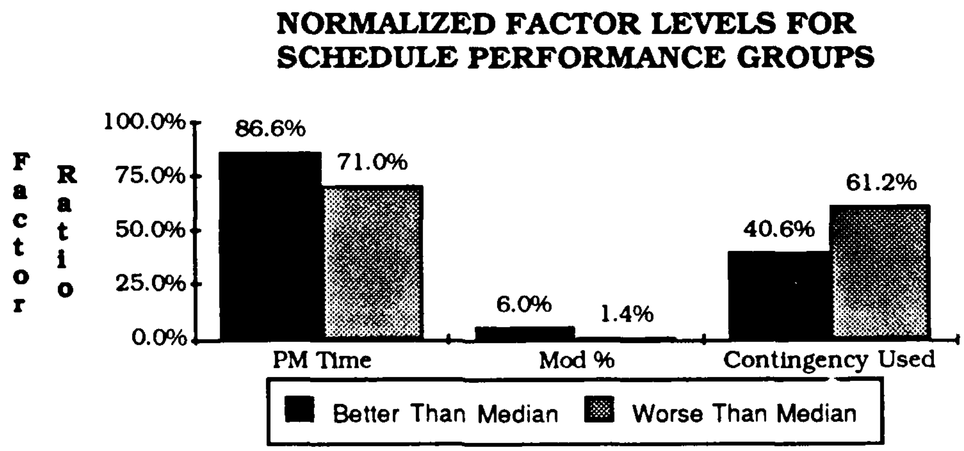


Figure 4.8: Levels of Normalized Factors For Projects Grouped According to Schedule Performance

IV.5 Budget Performance

IV.5.1 Factors Which Cause Budget Differences

Factors for which different levels corresponded to significant differences in project budget performance are depicted in tabular form in Table 4.6 and graphically in Figures 4.9 and 4.10. Several relationships exist between factors and budget performance. Project managers whose educational background included a management degree were more successful in obtaining budget performance better than the norm. This is not surprising considering that most management programs are conducted by business schools and include some degree of financial and accounting training.

Projects which experienced a change in project manager differed from projects which did not when considering budget performance. It appears that the discontinuity related to the project manager change has a negative effect upon project cost. We cannot, however, discount the possibilility that the project manager's were changed because of poor budget performance.

Project cost performance was better on projects where the project manager had a high level of authority regarding project design. This is opposite the earlier finding regarding the impact of project manager design authority on project schedule performance, where greater authority corresponded to poorer performance.

BUDGET PERFORMANCE DIFFERENCES BASED ON FACTOR MEASURE LEVELS

Null Hypothesis: The difference between the mean of the *budget difference from estimated* for high or positive factor levels and the mean of the *budget difference from estimated* for low or negative factor levels is equal to zero (no difference).

Alternate Hypothesis: The difference between the mean of the *budget difference from estimated* for high or positive factor levels and the mean of the *budget difference from estimated* for low or negative factor levels is greater than (or less than) zero.

FACTOR MEASURE	BUDGET PERFORMANCE HIGHER LEVEL	LOWER LEVEL	% DIFF FROM LOWER	SIG LEVEL
PROJECT MANAGER				
Design Authority (high/low)	-4.0%	6.5%	-9.9%	.034
Education Type (mgmt/engr)	-10.6%	-1.2%	-9.6%	.085
Changed During Project (no/yes)	-4.8%	0.0%	-4.8%	.130
PROJECT TEAM				
Design Contract Penalty (yes/no)	-13.7%	-1.4%	-12.5%	.011
Design Incentives (yes/no)	-9.7%	-2.5%	-7.4%	.093
Owner Tech Exp (high/low)	-4.7%	-0.3%	-4.9%	.125
Designer Tech Exp (high/low)	-4.9%	-0.1%	-5.0%	.130
Constructor Incentives (yes/no)	-7.0%	-1.3%	-5.8%	.145
PLANNING				
Formal Risk ID (yes/no)	-7.6%	2.0%	-9.4%	.009
Constructability (yes/no)	-4.1%	3.6%	-7.4%	.060
PROJECT CONTROLS				
CPM Used (yes/no)	-3.7%	4.9%	-8.2%	.070
Communications (formal/infor)	-7.5%	-0.5%	-7.0%	.070
Liaison Personnel (yes/no)	-5.7%	0.1%	-5.8%	.089

Table 4.6: Differences in Budget Performance Based on Factor Measure Levels

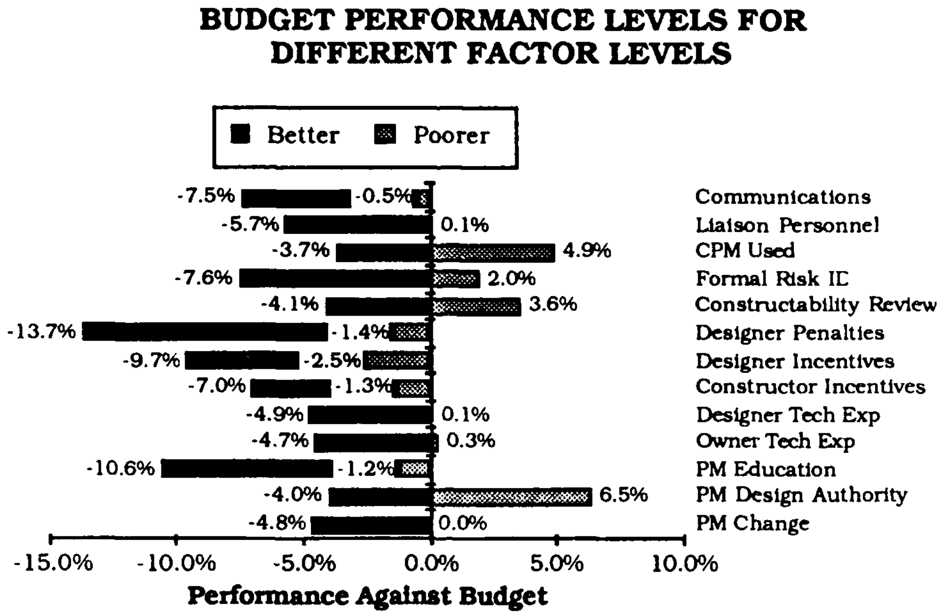


Figure 4.9: Budget Performance For Projects Grouped According to Factor Levels

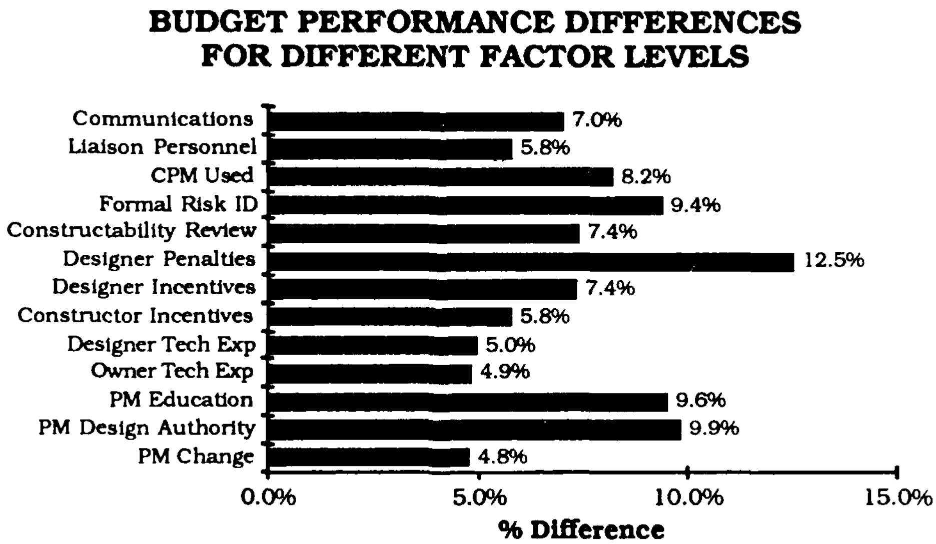


Figure 4.10: Differences in Budget Performance For Projects Grouped According to Factor Levels

Project budget performance differed between project categories determined by the existence of incentives for both the designer and the constructor. In both cases, the inclusion of incentive clauses in the contracts corresponded to better performance against the project budget. Technology experience on the part of project team members also appears to impact favorably on project costs, with higher technology experience on the part of the owner or the designer corresponding to better budget performance. This supports the earlier findings regarding the relationship between technical experience and schedule performance.

Findings regarding the existence and nature of constructability programs also support earlier findings. A formal program appears to exert a positive influence upon budget performance as well as schedule performance. Formal risk identification programs also corresponded to better project cost performance. This is a strong indication that the formal analysis of risk allows a better estimate of cost and hence better performance against the budget.

The use of the Critical Path Method for project schedule control appears to exert a positive influence upon budget performance. A possible explanation for this outcome is the positive impact upon effective labor utilization exerted by tight controls upon material and equipment scheduling. Less wasted time improves productivity and reduces costs, causing better performance against the budget.

Differences in some project communication characteristics also appear to influence budget performance. Projects which depended upon more formal means of

communication (meetings, correspondence) for the majority of information transfer performed better against the budget. Additionally, projects where communications were enhanced by the use of liaison personnel also experienced better budget performance. These findings seem to indicate that more complete communications can cause an improvement in project budget performance.

IV.5.2 Differences Between Budget Performance Groups

Table 4.7 depicts those factors which demonstrated significant differences between projects with budget performance better than the median and those with budget performance worse than the median. These groups were also similar to those determined by project class. 92% of the better performing projects with respect to budget were classified as outstanding while 85% of the poorer budget performing projects were classified as average.

Some project manager characteristics differed significantly between projects categorized according to budget performance. Project managers on projects with better budget performance had significantly more technical experience. This reinforces the earlier findings regarding the impact of technical experience of the project team. Projects with better budget performance had fewer meetings involving the project manager and a deeper hierarchy. Although different from what we might have expected, the project hierarchy result mirrors the earlier findings regarding the relationship between project size and project success. It also indicates, however, that the relationship

FACTOR DIFFERENCES BASED ON BUDGET PERFORMANCE LEVELS

Null Hypothesis: The difference between the mean of the *factor levels* for projects with performance against budget better than the median and the mean of the *factor levels* for projects with performance against budget worse than the median is equal to zero (no difference).

Alternate Hypothesis: The difference between the mean of the *factor levels* for projects with performance against budget better than the median and the mean of the *factor levels* for projects with performance against budget worse than the median is less than (or greater than) zero.

FACTOR MEASURE	BUDGET PERFORMANCE BETTER	BUDGET PERFORMANCE WORSE	% DIFF FROM POORER	SIG LEVEL
PROJECT MANAGER				
PM Tech Experience (# proj)	5.7	1.8	223.7%	.026
Project Levels	5.8	5.0	15.4%	.042
PM Meetings (#/wk)	2.7	5.5	-51.2%	.104
PROJECT TEAM				
Team Turnover (%/mo)	7.2%	18.7%	-61.4%	.028
Lost Time Severity	51.0	178.1	-71.4%	.126
PLANNING				
Contingency Used (% budg)	21.2%	81.9%	-74.1%	.000
Design Complete at Start (%)	69.9%	51.0%	37.1%	.061
Execution Plan Detail	8.4	6.0	39.7%	.098
Budgeted Contingency (% cost)	9.1%	6.9%	32.3%	.131
PROJECT CONTROLS				
Control Mtg Frequency (#/wk)	1.36	0.93	46.6%	.128
Control System Cost (% cost)	1.3%	0.8%	77.8%	.144

Table 4.7: Differences in Factor Levels Based on Budget Performance

is not solely based on the greater satisfaction derived from the successful completion of larger projects but may also be related to an as yet undetermined relationship between deeper

hierarchies and improved cost performance. These results are depicted graphically in Figure 4.11.

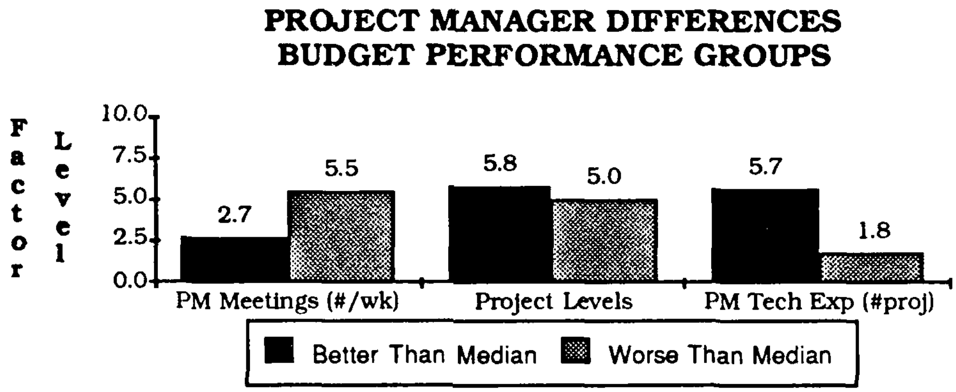


Figure 4.11: Project Manager Differences Between Projects Grouped According to Budget Performance

Figure 4.12 shows the differences between the groups for project team turnover and project lost time severity. These findings support the earlier hypotheses regarding the relationships between these factor measures, budget performance, and project classification. In both cases, the factor measure appears to influence a critical criteria for success, rather than the determination of success itself.

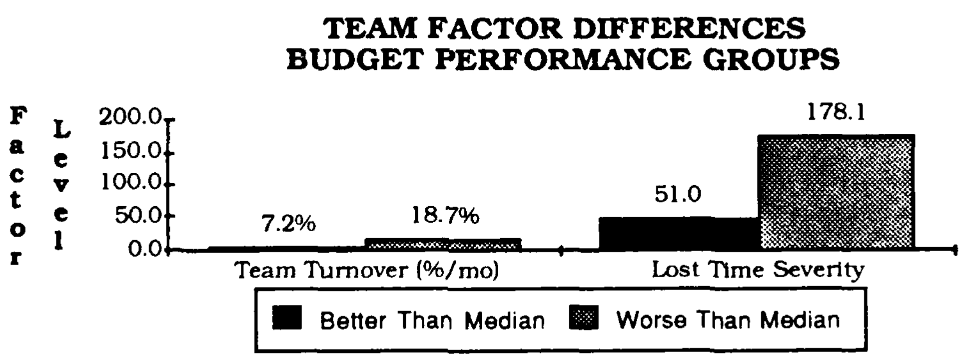


Figure 4.12: Project Team Differences Between Projects Grouped According to Budget Performance

Figure 4.13 depicts the Planning factors which demonstrated significant differences between projects grouped according to budget performance. Projects with better budget performance had a greater portion of detailed design complete at the start of construction. This improved performance is probably the result of the better construction planning which the early receipt of drawings allows. Alternately, it could be the result of a decrease in the number of changes which may result from earlier completion of engineering. Our findings regarding changes fail to support a similar hypothesis, as changes did not differ significantly between projects based on budget performance. Based on our earlier finding regarding the relationship between changes and project classification, it is possible that changes are a measure upon which projects are evaluated, separate from project cost and schedule performance.

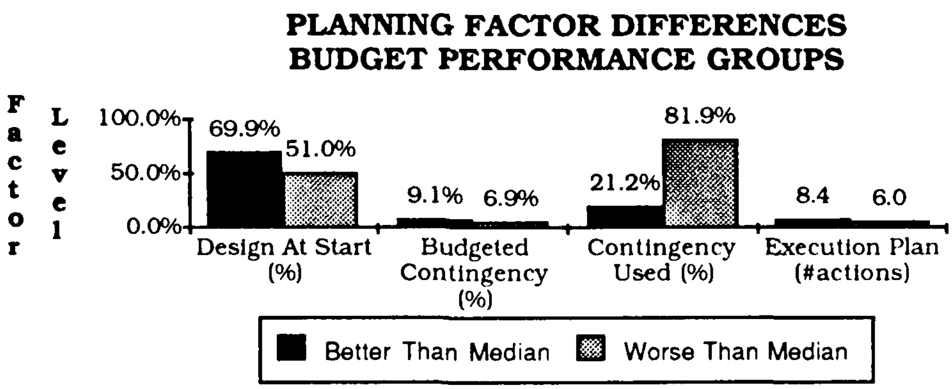


Figure 4.13: Planning Differences Between Projects Grouped According to Budget Performance

Projects with better cost performance had a greater portion of their budgets devoted to contingency. While this finding might have been predicted, it raises the possibility that

better cost performance is more the result of less stringent cost objectives than it is of improved project performance.

Project execution plans appear to be a factor in budget performance as well. Projects with better budget performance had more detailed execution plans. This supports long-held construction industry beliefs that better planning will lead to better project performance. Other factors which demonstrated significant differences between projects classified according to budget performance included the frequency of engineering control meetings and the cost of control systems (Figure 4.14). Although each of these items indicates a greater investment of management time and effort, this investment appears to be cost effective.

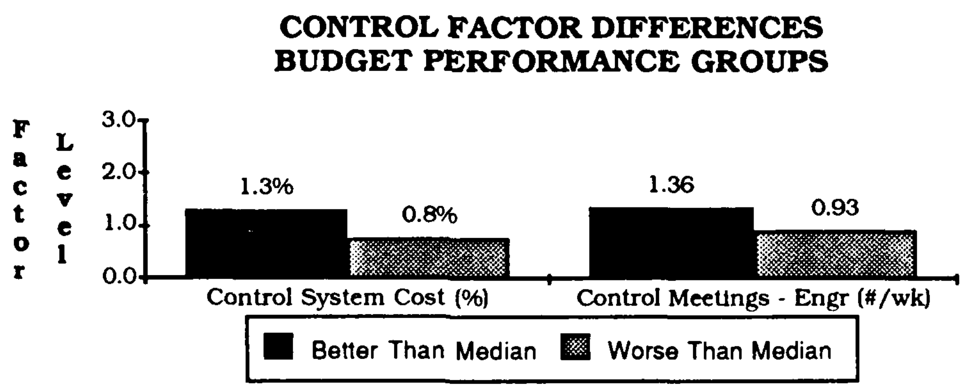


Figure 4.14: Control System Differences Between Projects Grouped According to Budget Performance

IV.6 Factors Which Do Not Differ For Any Classification

Several factor items did not appear to differ significantly between the various classifications or correlate to differences

between outcomes based on the factor levels. Although we do not intend to assert here that these items have no impact, the findings may have significant implications.

Project managers on successful projects did not visit projects sites any more or less frequently than project managers on less successful projects. Although previously stated findings appear to indicate that a high degree of project manager involvement is beneficial, it appears that fruitful involvement does not necessarily demand involvement at the lowest levels but rather requires a large amount of effort at tasks which are the project manager's responsibility.

No difference was found between classifications for the number of projects under the project manager's supervision during the period of the project under evaluation. This should not be interpreted as an indication that project manager involvement is not important to successful outcomes, as earlier findings identified significant differences related to the portion of the project manager's time devoted to the project under evaluation. It appears that this finding is mitigated by the amount of time that the project manager devoted to one principal project, which also happened to be the project offered for inclusion in this study.

Also failing to influence project outcomes was the existence (or lack thereof) of prior project relationships between the various parties (client, designer, constructor). Additionally, the utilization of a single contractor for design and construction was not significantly advantageous. These findings seem reasonable considering the professional organizations involved, the level of competition within the industry, and the

use of invitation-only bidding by most of the respondents. A somewhat more surprising finding related to the Project Team was the apparently insignificant effect of greater experience on the part of the participants with projects of a similar or larger scope.

Other important items which did not reflect significant differences between classes included the relative cost of the design, the level of detail of Standard Operating Procedures, and the establishment of specific goals by the client or owner. In the case of design cost, the findings appear to indicate either a limited impact of design cost on project outcomes or that spending more money for the design is no guarantee of a better or more effective product. Regarding client goals, the specification of goals or objectives by the client in areas other than cost or schedule (e.g., productivity, safety, sub-account costs) appears to have no impact upon project outcomes.

CHAPTER V

INTERPRETATION OF RESULTS

Our analysis has evaluated differences for project characteristics, project performance, and project inputs between projects classified as outstanding and those classified as average; between projects with budget performance better than the sample median and those with budget performance worse than the sample median; and between projects with schedule performance better than the sample median and those with schedule performance worse than the sample median. Additionally, we have evaluated the differences for project schedule performance and project budget performance between projects categorized according to levels of project inputs. Based on this analysis and our ability to establish with some certainty the existence of differences between categories, certain actions are indicated for managers within the construction industry for each of the factor categories, at least for managers who consider cost and schedule performance when evaluating the success of a project. Additionally, our research has identified several areas which may benefit from additional analysis. The remainder of this chapter is devoted to a discussion of our findings and recommendations.

V.1 Management Actions Indicated

V.1.1 Project Manager

Several characteristics related to project managers appear to affect project outcomes. Based on our findings, the following recommendations are made:

1. Project manager's should be selected on the basis of previous experience as a project manager and previous total construction experience. The size and type of projects on which that experience has been gained appear to be a secondary concern. Of the two, experience with a similar technology appears to be more important, particularly if schedule considerations are paramount.

2. Project managers must be allowed to devote their attention and efforts to a primary project. Although successful project managers were able to manage concurrent projects, project managers on the successful projects devoted more of their time to the project under consideration than the project managers on the average projects.

3. Consideration should be given to locating the project managers at the site or in the contractor's offices when applicable.

4. Project manager authority should not be an overriding consideration when defining project objectives. In fact, matrix-type organizations with less authority vested in one individual appear to be more successful.

5. Project managers should not be changed during the course of a project unless organizational requirements demand it or project performance is less than desired.

6. Consideration should be given to affording project managers the opportunity to obtain management related degrees. This appears to positively affect project costs which should allow the organization to recapture this investment.

V.1.2 Project Team

Our findings suggest consideration of the following recommendations related to the project team:

1. Attention must be given to project safety performance due to an apparent significant effect upon both project cost and project schedule performance.

2. Project team turnover should be kept to a minimum to avoid adverse cost and schedule impacts.

3. Prequalification and selection of primary contractors (engineering and construction) should give significant consideration to the contractor's prior experience with similar technology.

4. The use of contract incentives should be considered for both designers and constructors, particularly if cost performance is an important consideration.

5. Qualification and selection of contractors should place limited emphasis upon the existence of previous

relationships between the parties as this does not seem to significantly affect project outcomes.

V.1.3 Planning

The following considerations appear to be important for success when planning construction projects:

1. Projects should receive a formal constructability review, with careful consideration given to opportunities for modularization. It appears that a positive influence on both cost and schedule may result.

2. Effort should be made to accomplish as much of the detailed design as possible prior to the start of construction, consistent with other schedule considerations.

3. A formal program for risk identification and management should be considered to better identify costs prior to project execution.

4. Managers should consider including greater detail in execution plans because of the favorable impact upon budget performance which may result.

V.1.4 Controls

Specific actions related to project controls which should be considered include the following:

1. Continuous or frequent updates to the control budget to reflect approved scope changes should be accomplished.

2. Tight schedule control should be maintained to achieve better cost performance.

3. Although informal communications are to be encouraged, they should not be considered a substitute for the formal transfer of information which occurs by correspondence and formal meetings.

4. Additional expenditures for control systems should be considered to assist in obtaining favorable budget performance and favorable project outcomes.

5. Consideration should be given to co-locating owner and client project offices as positive schedule differences appear to result. A suitable alternative may be the use of liaison personnel to enhance communications.

V.2 Questions Raised

The study demands additional analysis in a variety of areas. Four major categories of issues remain unresolved. Additional measures or criteria for project classification, particularly those of a subjective nature, remain unevaluated. Additionally, most of the recommendations included above do not list specific actions, procedures, or expenditures for managers. An obvious question in this regard is the amount of the optimal investment, in either time or money, for a particular management action. A third unresolved issue is the implications related to those particular items or actions which

failed to demonstrate significant differences for any analysis category or for particular categories. Finally, the interrelationships between factors, including the inherent tradeoffs, requires evaluation. Each of these issues will be addressed in turn in the following paragraphs.

V.2.1 Other Success Measures

Of the many criteria which may influence a determination of a project as successful, we have only adequately analyzed the purely objective ones. An obvious emphasis has been placed on cost and schedule, in part because they are easily evaluated, but also because of the strong evidence which has been presented in this thesis supporting the finding that these are key criteria. Although efforts were made to evaluate the technical performance of the projects under study, very limited results were obtained, rendering analysis impossible. As stated earlier, we feel that these circumstances alone allow preliminary conclusions regarding the lack of significance of this particular criteria.

Categorization of a project as successful results from the attainment of satisfaction, regardless of the reasons behind those satisfactions. The previous research in this project evaluated several largely subjective issues related to project classification, to include team satisfaction, client satisfaction, capabilities build-up, follow-on work, and others. It appears obvious that achievement of the above objectives is related to some other measure of project performance. It is difficult to conceive that most clients would be satisfied if a project cost them significantly more than planned. At the very least, less

satisfaction would result. While our study fails to address the relationships between project performance and these subjective satisfactions, it is seems probable that a large portion of the underlying performance measures are related to cost and schedule performance. Consequently, this study will be of value to most players in the construction industry.

Other project performance characteristics were also successfully evaluated. Project safety performance, project changes, and turnover within the project team each differed between average and outstanding projects. Safety performance and turnover also differed between projects categorized according to budget and schedule performance. Consequently, these items could be related to successful projects because of the satisfactions provided by them alone or because of their impact on cost and schedule performance. The relationship also may be a combination of the two possibilities.

Based on this discussion, research is indicated to resolve the following questions:

1. Which project performance characteristics provide the satisfactions for a particular class of respondent which lead the classification of the project as successful?

2. To what degree are outcomes related to safety, changes, or quality satisfiers? To what degree are these outcomes factors related to schedule and budget performance?

3. Which factors are determinants of safety, changes, quality, or other outcomes?

V.2.2 Level or Degree of Actions Indicated

Several questions regarding the degree, quantity, amount, or other measure or level of the activities prescribed earlier in this chapter must be raised and resolved for the recommendations to realize their fullest value. Although we have identified the existence of differences between categories, our data only allows determination of a range of possible values for the size of the difference. A more detailed and specific study of the following issues is indicated to resolve this particular question:

1. What portion of the project manager's time is required to obtain the positive benefits indicated?

2. How much experience is desirable on the part of the project manager?

3. In whom should the management authority be vested? How much authority for the different participants?

4. How much should be invested in a formal risk analysis to enhance the possibilities for a maximum return of this particular investment?

5. What items should be included in a Project Execution Plan? What level of detail is demanded?

6. What is the appropriate investment in design and engineering to achieve a maximum return on this investment?

7. What portion of the design should be completed prior to construction to achieve the potential positive results indicated earlier?

8. What is an appropriate investment in constructability? What constructability issues are most critical?

9. What portion of a budget should be invested in control systems to obtain a maximum return on this investment?

V.2.3 Interrelationships

A related issue to that of the level or degree of a factor is the existence of interrelationships between multiple factors and outcomes. A detailed analysis of the impact of multiple factors in concert with one another is beyond the scope of the immediate study. However, our findings raise significant questions about several possible interrelationships which must be considered.

1. The finding related to the impact of contract incentives requires consideration of contract type due to the incentives inherent in certain contracts. For instance, it is possible that incentives may not be necessary where the contractual relationship rewards better cost performance on the part of the contractor.

2. Efforts to enhance project communication appear to be effective in obtaining improved project performance. These efforts involve a trade-off between the relative location of key parties and individuals on the project team and the implementation of specific actions to enhance communications (e.g., meetings, liaison personnel).

3. Findings regarding project size and hierarchy require an evaluation of the interrelationship between the two. Of particular interest is the somewhat surprising finding related to the depth of the project hierarchy and project outcomes.

4. Related to the hierarchy and project size issue is the degree of project manager involvement in terms of time devoted to the project and the number of projects under the manager's supervision. The capabilities of the remaining members of the project team must also be considered as the possibility exists that management may consciously assign their better performers to the larger projects.

5. The relationship between risk analysis, contingency, and project outcomes should be evaluated due to the apparent impact of the factors and the obvious relationship among them.

V.2.4 Lack of Findings or Data

We have been unable to resolve several issues which fall within the original scope of this study. The inability to do so is largely based upon difficulties encountered in identifying and capturing objective measures for all the factors under study. Related to this is our inability to identify measures which would allow us to discriminate between projects for a particular factor. As a result, the following issues remain unresolved:

1. Our evaluation of the capabilities and experience of the project team was limited to an evaluation of the experience of the particular organizations involved. For this reason we can draw no conclusions related to the requirement for particular

skills on the project team or related to the impact of varying levels of experience among the team members.

2. Similarly, motivation was considered only from an organizational standpoint. We cannot comment on the potential impact of motivational programs designed to improve worker motivation.

3. Using our criteria for the establishment of levels of project team experience with projects of a similar size, almost all organizations received a "high" rating. As a result, the findings failed to identify a significant difference between projects based on this classification. Additional projects having low levels of experience on similar size projects on the part of project team organizations must be included in our database before we are able to draw any conclusions in this regard.

4. Insufficient detailed information was gathered regarding rework to evalute either the possible causes for rework or the impact of rework upon project outcomes. A detailed study in this regard is necessary in order to draw any conclusions.

5. Our methods of measuring levels of owner authority and influence failed to identify discriminating factors between projects, although differences obviously exist. An objective, quantifiable measure must be identified and evaluated before any recommendations can be made in this regard.

V.3 Concluding Comments

This study has sought to identify factors or project management decisions and inputs which contribute to outstanding project outcomes. Some of the findings may appear startling either in the apparent effect or the lack of effect of a factor. It is necessary to emphasize that we are searching for those items which differentiate average and outstanding projects. This study has not sought to identify the minimum necessary actions or inputs for management. The failure of a factor to demonstrate significant differences between average and outstanding projects does not indicate that the factor is not important to the projects. In fact, the particular input may be mandatory for both an average and a successful outcome. This lack of a finding merely suggests that the application of additional time or money to the particular input may do very little to improve outcomes over the average or expected.

The reader must evaluate our findings in light of Table 3.1 presented earlier regarding the composition of the data sample. The most significant limitations relate to the preponderance of process plant projects within the industrial category. For this reason, our findings can only be applied with a reasonable degree of certainty to projects which fall within a similar category. Considering what many feel to be the universal nature of project management, however, it is believed that only limited caution is necessary in this regard.

The initial intent of this phase of the research was the further culling from the list of possible factors those which contribute to achieving construction project success above that normally expected. Consistent with that desire, Table 5.1

depicts our findings related to the 21 factors presented in Chapter III. As we typically analyzed detailed project inputs related to the factors and not the factors themselves, an indication of impact in the table reflects an impact of any or several of the related inputs.

While we have not been totally successful in limiting the number of factors for further study, we have been able to provide specific recommendations and have also been successful in identifying specific areas requiring additional analysis. In light of this, we maintain a strong conviction that continued research in this area will eventually lead to the establishment of a baseline for project performance above what is presently experienced.

IMPACT OF FACTORS ON OUTSTANDING OUTCOMES

FACTOR	IMPACT ON CLASS	IMPACT ON SCHEDULE	IMPACT ON BUDGET
Project Manager			
PM Commitment and Involvement	X	X	X
PM Authority		X	
PM Education and Experience	X		X
Project Team			
Team Capabilities and Experience	*	X	X
Team Motivation	*		X
Team Stability	X		X
Team Orientation	*		
Safety	X	X	X
Planning			
Design			X
Scope Definition	X		
Cost Estimate	X		
Constructability	X	X	X
Risk Identification and Management	*	X	X
Preplanning			X
Project Controls			
Control Systems	X		X
Communications	*	X	X
Design Interface Management			
Standard Operating Procedures			
Other Factors			
Owner Authority and Influence	*	X	
Owner Goals			
Technical Uncertainty	*	X	

*Not evaluated due to nature of the available data.

Table 5.1: Impact of Factors on Outstanding Outcomes

APPENDIX A

DATA SHEET

DETERMINANTS OF CONSTRUCTION PROJECT SUCCESS

PROJECT DATA SHEET

PROJECT NUMBER ____

COMPANY ________________

Investigators:

Edward J. Jaselskis
Rory A. Salimbene
David B. Ashley

College of Engineering
Civil Engineering Department
Construction Engineering and Project Management
University of Texas at Austin
Austin, Texas 78712-1076

CONFIDENTIAL PROJECT DATA

Project No.:_________

Project Name:	_______________
Project Location (name):	_______________
Company Code:	_______________
Company Name:	_______________
Respondent Last Name:	_______________
Respondent First Name:	_______________
Respondent Current Position:	_______________
Respondent Project Position:	_______________
Address:	_______________
	_______________
City:	_______________
State:	_______________
Zip Code:	_______________
Area Code:	_______________
Phone Number:	_______________
Owner:	_______________
Constructor:	_______________
Designer:	_______________

PROJECT INFORMATION

Project No.:_________

Project Classification:							avg	out
Location:							dom	intl
Construction Industry:					coml	ind	res	civ
Technology Type:	ext	proc	pow	man	off	whse	civ	oth
Construction Classification:					grass.oots		revamp	
Year Completed:							_________	
Project Duration (mos):							_________	
Actual Project Cost ($mm):							_________	
Final Estimated Cost ($mm):							_________	
Project Cost Difference (% of estimated):							_________	
Actual EPC Duration (mos):							_________	
Planned EPC Duration (mos):							_________	
EPC Duration (% of planned):							_________	
Actual Construction Duration (mos):							_________	
Planned Construction Duration (mos):							_________	
Construction Duration (% of planned):							_________	
Actual Facility Output:							_________	
Planned Facility Output:							_________	
Output Difference (% of planned):							_________	
Actual Construction Manhours (m):							_________	
Estimated Construction Manhours (m):							_________	
Construction Manhours (% of estimated):							_________	
Actual Engineering Duration - 90% (mos):							_________	
Estimated Engineering Duration - 90% (mos):							_________	
Engineering Duration (% of estimated):							_________	
Construction Workers at Peak:							_________	
Total Project Manhours (m):							_________	
Respondent Organization Class:				owner			contractor	
Respondent Organization Type:				owner		const		des
Respondent Project Position:				PM	CM	PE	CE	other

PROJECT MANAGER

Project No.:_________

Committment and Involvement

PM Change:			yes______no		
PM Assignment (mos from start):			__________		
PM Assignment Timing (% of duration):			__________		
PM Location (home,client,site):			__________		
PM Meeting Freq (#/wk):			__________		
PM Site Visit Freq (#/mo):			__________		
Projects Supervised by PM (#):			__________		
PM Personal Subordinates (#):			__________		
Project Levels, PM to Crafts (#):			__________		
PM Time Devoted to Project (% of work):			__________		

Authority

PM Design Authority:			unl	lim	none
PM Change Limit (% of total cost):				__________	
PM Team Selection:		unl	sel	rec	none
PM Contractor Selection:		unl	sel	rec	none
PM Budget Authority:		unl	lim	req	none
PM Budget Shift Limit (% of total cost):				__________	
PM Control Authority:		unl	lim	rep	none

Education and Experience

PM Education Level:	hs	aso	bac	mas	hd
PM Education Area:		engr	tech	mgmt	other
PM Experience, Similar Scope (# proj):				__________	
PM Experience, Similar Technology (# proj):				__________	
Total PM Experience (years as PM):				__________	
Other Experience, Similar Scope (# proj):				__________	
Other Experience, Similar Technology (# proj):				__________	
Total Other Construction Experience (years):				__________	
PM Total Experience, Similar Scope (# proj):				__________	
PM Total Experience, Similar Technology (# proj):				__________	
PM Total Construction Experience (years):				__________	

PROJECT TEAM

Project No.:__________

Capabilities and Experience

Similar Scope Experience (high,med,low,none):

Owner:	high	med	low	none
Designer:	high	med	low	none
Constructor:	high	med	low	none

Similar Technology Experience (high,med,low,none):

Owner:	high	med	low	none
Designer:	high	med	low	none
Constructor:	high	med	low	none

Motivation

Incentives to Subcontractors:				yes______no	
Constructor Contract Type:	rcf	rcp	ls	up	ih
Designer Contract Type:	rcf	rcp	ls	%	ih
Constructor Incentives:				yes______no	
Constructor Incentive Basis:	cost	sched	subj	other	n/a
Constructor Incentive Amount (% of contract amount):				__________	
Designer Incentives:				yes______no	
Designer Incentive Basis:	cost	sched	subj	other	n/a
Designer Incentive Amount (% of contract amount):				__________	
Total Incentive Amount ($mm):				__________	
Total Incentive Amount (% of total cost):				__________	
Constructor Penalties:				yes______no	
Constructor Penalty Basis:	cost	sched	subj	other	n/a
Constructor Penalty Amount (% of contract amount):				__________	
Designer Penalties:				yes______no	
Designer Penalty Basis:	cost	sched	subj	other	n/a
Designer Penalty Amount (% of contract amount):				__________	
Total Penalty Amount ($mm):				__________	
Total Penalty Amount (% of total cost):				__________	

Team Stability

Respondent Project Team Turnover (%/yr):	__________
Work Force Turnover (%/mo):	__________

Team Orientation

Owner/Constructor Previous Job:	yes______no
Owner/Designer Previous Job:	yes______no
Constructor/Designer Previous Job:	yes______no
Owner/Designer/Constructor Previous Job:	yes______no
Same Contractor, Design and Construct:	yes______no
Respondent Team Previous Team Experience:	yes______no
Subcontract Construction Manhours (m):	__________
Subcontract Construction (% of total):	__________

Safety

Safety Program Budget ($mm):	__________
Safety Program Budget (% of total cost):	__________
Safety Inspection Frequency (#/wk):	__________
Safety Training (hrs/worker/wk):	__________
New Hire Safety Orientation:	yes______no
Project Lost Time Rate:	__________
Project Lost Time Cases:	__________
Project Lost Time Severity Rate:	__________
Project Lost Time Days:	__________
Construction Related Deaths:	__________
Safety Records Maintained:	yes______no

PLANNING

Project No.:_________

Design

Design Cost ($mm): __________
Design Cost (% of total cost): __________
Rework manhours (m): __________
Rework manhours (% of construction mhs): __________

Scope Definition

Design Percentage at Construction Start (%): __________
EPC Duration Prior to Construction Start (mos): __________
EPC Duration Prior to Construction Start (% EPC duration): __________
Change Order Cost ($mm): __________
Change Order Cost (% of total cost): __________

Cost Estimate

Computerized Cost Estimating: yes______no
Actual Productivity: __________
Estimated Productivity: __________
Productivity Estimate Accuracy (% difference): __________
Actual Labor Rate ($): __________
Estimated Labor Rate ($): __________
Wage Rate Estimate Accuracy (% difference): __________
Actual Material Cost ($mm): __________
Estimated Material Cost ($mm): __________
Material Estimate Accuracy (% difference): __________

Constructability

Prefabrication and Modularization (% of construction cost): __________
Constructor Design Review: comp lim none
Constructability Program: form infor none

Risk Identification and Management

Formal Risk Identification:	yes_____no
Owner Controlled Insurance Program:	yes_____no
Budgeted Contingency ($mm):	__________
Budgeted Contingency (% of estimated cost):	__________
Contingency Used ($mm):	__________
Contingency Used (% of budgeted contingency):	__________

Preplanning

Manhours Prior to Construction (% of EPC mhs):	__________
Activities in Execution Plan (#):	__________
Items in Project Execution Plan:	
Job Descriptions:	yes_____no
Cash flow:	yes_____no
Manpower Loading:	yes_____no
Personnel Assignments:	yes_____no
Critical Equipment:	yes_____no
Contracts:	yes_____no
Detailed Schedule:	yes_____no
Risks/Uncertainties:	yes_____no
Activity Planning:	yes_____no
Project Inspections:	yes_____no
Quality Control Program:	yes_____no
Safety Program:	yes_____no
Equipment Yard:	yes_____no
Procurement:	yes_____no
Tool Controls:	yes_____no
Incentive Programs:	yes_____no

CONTROLS

Project No.:_________

Control Systems

Schedule Control Technique Used:

CPM/Logic Network:	yes_____no
Bar Chart:	yes_____no
Work Breakdown Structure:	yes_____no
Cost Control Data Collection (#/wk):	__________
Cost Reports (#/mo):	__________
Construction Management Cost ($mm):	__________
Construction Cost ($mm):	__________
CM Cost (% of construction cost):	__________
Formal Progress Inspections (#/wk):	__________
Formal Quality Inspections (#/wk):	__________
Formal Safety Inspections (#/wk):	__________
Total Formal Inspections (#/wk):	__________
Control Systems Cost ($mm):	__________
Control Systems Cost (% of total cost):	__________
Engineering Control Meetings (#/wk):	__________
Construction Control Meetings (#/wk):	__________
Schedule Updates (#/yr):	__________
Control Budget Updates (#/yr):	__________

Communications

Owner/Contractor Project Offices Co-located:	yes_____no
Owner/Contractor Liaison Personnel:	yes_____no
Owner PM On Site/At Design Office:	yes_____no
Contractor PM On Site:	yes_____no
Project Newsletter:	yes_____no
Computerized Data Transfer:	yes_____no
External Communications On Organization Charts:	yes_____no
Primary External Communication:	mtg writ indf indt

Design Interface Management

Design Team Meetings (#/wk):	__________
Drawing Reviews/Checks (avg #/dwg):	__________

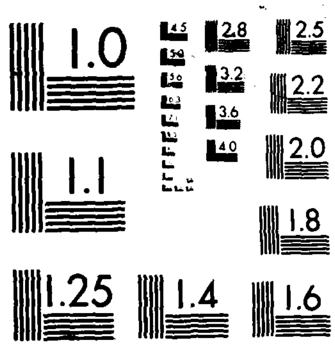
<u>Standard Operating Procedures</u>

Activities in Standard Procedures (#):	__________
Standard Operating Procedure For:	
Project Hiring/Firing:	yes______no
Daily Schedule:	yes______no
Foreman Planning:	yes______no
Inspections:	yes______no
Equipment Yard:	yes______no
Incentives:	yes______no
Project Reports:	yes______no
Meetings:	yes______no
Subcontractor Planning:	yes______no
Quality Control Procedures:	yes______no
Procurement:	yes______no
Preplanning:	yes______no
Accounting:	yes______no
Design Procedures:	yes______no
PM Planning:	yes______no
Safety Program:	yes______no
Tool Controls:	yes______no

AD-A175 196 AN OBJECTIVE EVALUATION OF DETERMINANTS OF CONSTRUCTION PROJECT SUCCESS(U) ARMY MILITARY PERSONNEL CENTER ALEXANDRIA VA R A SALIMBENE DEC 86 2/2

UNCLASSIFIED F/G 5/1 NL

END
2 87
DTIC



ROCOPY RESOLUTION TEST CHART

EXTERNAL FACTORS

Project No.:_________

Owner Authority and Influence

Owner Contact Change Approval Limit ($mm):	__________
Owner Contact Change Approval Limit (% of total cost):	__________
Change Approval Time (avg # of days):	__________
Total Material Cost ($mm):	__________
Owner Supplied Material Cost ($mm):	__________
Owner Supplied Construction Materials (% of total matls):	__________
Owner Approval of Subcontractors:	yes_____no
Owner Approval of Constructor Personnel:	yes_____no
Owner Approval of Designer Personnel:	yes_____no

Owner Goals

Owner Specified Goals (# of areas):	__________
Owner Specified Goals For:	
Total Cost:	yes_____no
Completion Date:	yes_____no
Safety:	yes_____no
Quality/Rework:	yes_____no
Productivity:	yes_____no
Major Sub Account Costs:	yes_____no
Absenteeism:	yes_____no
Turnover:	yes_____no

Technical Uncertainty

Team Technology Experience:	high	med	low	none
Project Complexity Regarding:				
Construction Methods:	high	med	low	none
Temperature Requirements:	high	med	low	none
Pressure Requirements:	high	med	low	none
Quality Requirements:	high	med	low	none

BIBLIOGRAPHY

Ashley, David B., Jaselskis, Edward J., and Lurie, Clive B. "The Determinants of Construction Project Success." Paper submitted for publication, The University of Texas, 1986.

"Construction Economics." Engineering News Record, (January 23, 1986), pp. 53-58.

de Wit, Anton. "Measuring Project Success: An Illusion." 1986 Proceedings, Project Management Institute, pp. 13-21.

Herbsman, Zohar J. "Realistic Production Rates the Key For Measuring Construction Success." 1986 Proceedings, Project Management Institute, pp. 348-353.

Jolivet, François, and Spie Batignolles. "The Possibility of Anticipating, Several Years in Advance, the Success or Failure of a Project." 1986 Proceedings, Project Management Institute, pp. 35-39.

Kothari, Ashok K. "Success in Project Management." 1986 Proceedings, Project Management Institute, pp. 240-246.

Mendenhall, William, and James E. Reinmuth. Statistics for Management and Economics, Fourth Edition Boston, Massachusetts: Duxbury Press, 1982.

Salapatas, J. N., and W. S. Sawle. "Measuring Success of Utility Projects Past Present and Future." 1986 Proceedings, Project Management Institute, pp. 67-76.

Tuman, John Jr. "Success Modeling: A Technique for Building a Winning Project Team." 1986 Proceedings, Project Management Institute, pp. 94-108.

VITA

Rory Alan Salimbene was born in Martins Ferry, Ohio, on October 27, 1956, the son of Shirley Irene Salimbene and Rocco Salimbene. After completing his work at Martins Ferry High School in 1974, he entered The United States Military Academy at West Point, New York. He received the degree of Bachelor of Science from The United States Military Academy in June, 1978, and was commissioned as a second lieutenant in the United States Army. Following successive assignments in the United States Army Corps of Engineers, he was promoted to his present rank of Captain. In September, 1985, he entered The Graduate School of The University of Texas.

Permanent Address: 54327 Maple Lane
Martins Ferry, Ohio 43935

END

2-87

DTIC